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ADOLF LIECHTI

1898—1946

Die Schweizerische Radiologie steht gegenwärtig in der zweiten Phase ihrer Entwicklung. Die erste Periode war die Pionierzeit, die fern von den Hochschulen nur getragen wurde von einzelnen kraftvollen Persönlichkeiten. Die zweite Periode kennzeichnet sich durch den Eingang unserer Wissenschaft in die medizinischen Fakultäten. Im vergangenen

Sommer erlitt diese akademische Equipe einen schweren Verlust durch den Hinschied ihres jüngsten Mitgliedes.

ADOLF LIECHTI, der 1898 in St. Urban im Kanton Luzern geboren wurde, entstammte bäuerlichen Verhältnissen. Diese Umwelt war für ihn in der ersten Schulzeit entscheidend und legte ihm in der Folge das Studium an der Eidgenössischen Technischen Hochschule in Zürich nahe, wo Ingenieure, Landwirte und Naturwissenschaftler für das praktische Leben ausgebildet werden. Er scheint aber daselbst nicht völlige Befriedigung gefunden zu haben, denn nach einem Unterbruch, den Militärdienst und Krankheit verursacht hatten, wandte er sich in Bern dem Medizinstudium zu und geriet damit in den Bann des berühmten Internisten HERMANN SAHLI. Nach dem Staatsexamen 1924 ging er nach Hamburg, um sich dort unter dem führenden Radiologen Deutschlands, HERMANN HOLTHUSEN, in medizinischer Radiologie auszubilden. Damit bekannte er sich zu jener Richtung, die mit Betonung eine möglichst exakte naturwissenschaftliche Grundlegung der Medizin erstrebte. Der Entschluss war umso origineller, als eine Anlehnung an die Chemie ebenso in Betracht kommen konnte, da diese damals im Brennpunkt der allgemein-naturwissenschaftlichen und damit auch der medizinischen Forschung stand. Indem ADOLF LIECHTI für die Röntgenologie optierte, wies er dass er klar die gewaltige Bedeutung voraussah, die der modernen Atomphysik innerhalb der Naturwissenschaften im Allgemeinen und der Medizin im Besonderen zukommen werden.

In der Tat täuschte er sich nicht seiner Berufung, denn sein ferneres Wirken rückte ihn rasch in die vorderste Reihe seiner Fachgenossen. Im Jahre 1929 eröffnete er in Bern eine Praxis als Röntgenologe, habilitierte sich gleichzeitig als Privatdozent für medizinische Radiologie an der dortigen Universität und wurde nach Ablauf von 8 Jahren, 1937, Professor für medizinische Radiologie. Mit der Schaffung eines solchen Lehrstuhls waren bereits vier schweizerische Universitäten vorangegangen. ADOLF LIECHTI kommt das Verdienst zu, seiner Disziplin ein solches Ansehen in Bern verschafft zu haben, dass die dortige Regierung auf Antrag der medizinischen Fakultät für ihn den fünften Lehrstuhl in der Schweiz errichtete. Aus unansehnlichen Anfängen schuf LIECHTI tatkräftig im Laufe weniger Jahre ein massgebliches Universitätsinstitut. Es zeichnet sich gegenwärtig vor allem dadurch aus, dass neben den notwendigen Untersuchungs- und Behandlungsräumen für die Kranken und neben Unterrichtslokalitäten eigentliche Forschungslaboratorien bestehen, wie sonst nirgends in der Schweiz. Wäre ADOLF LIECHTI ein längeres Wirken vergönnt gewesen, so hätte er bestimmt die Schaffung einer radiotherapeutischen Klinik erreicht, womit den Kranken in hohem Masse gedient sein würde.

Wenn wir bedenken, dass der Verstorbene neben der Universitäts-

tätigkeit an mehreren Spitälern Berns als praktischer Radiologe tätig war, so erfüllen uns seine zahlreichen Forschungen und Publikationen mit besonderer Hochachtung. Es gibt kein Gebiet der Strahlenkunde, auf dem LIECHTI nicht Wichtiges geleistet hat. Die beiden Wurzeln unserer Disziplin sind Physik und Biologie. LIECHTI selbst sagte: »Ohne genaueste Kenntnisse der physikalischen Grundlagen ist die erspriessliche Anwendung in der Medizin nicht denkbar.» Die Resultate seines dahingehenden Strebens fasste er 1939 zusammen in seiner *Röntgenphysik*, die mancher aus der Feder eines Physikers erwartet hätte. Dieses Buch, überall völlig kompetent, stammt aber von einem Arzt, der für Aerzte und deren Bedürfnisse schreibt. Die besondere physikalische Begabung LIECHTIS, die das erwähnte Lehrbuch erst möglich machte, kommt nun insbesondere zum Ausdruck in seinen technisch-konstruktiven Leistungen. Zwei Probleme hat er gelöst: Er konstruierte einen einfachen integrierenden Lichtzähler und schuf eine Apparatur, welche erlaubt, gezielte Röntgenaufnahmen des Herzens in jeder beliebigen und gewollten Phase der Herztätigkeit zu machen. In LIECHTIS Forschungslaboratorien sind aber nicht nur technische und physikalische Probleme bearbeitet worden. Im Vordergrund stand eigentlich die strahlenbiologische Forschung. Es ist hier unmöglich, alle einschlägigen Arbeiten LIECHTIS und seines Mitarbeiterstabes auch nur aufzuzählen. Wir beschränken uns auf die Nennung einzelner wichtiger Probleme, deren Lösung wenigstens erstrebt wurde. Lebenslänglich beschäftigte sich der Verstorbene mit der Erforschung des Mechanismus der biologischen Strahlenwirkungen. Der Wechselbeziehung von Strahlung und Substanz liegt ein physikalischer Primärvorgang zugrunde, der von den Atomphysikern geklärt ist, allgemeine Geltung hat und deshalb der speziellen Betrachtung der biologischen Substanz übergeordnet ist. Der physikalische Primärprozess ist Grund und Ausgang aller weiteren Reaktionsabläufe und führt zum biologischen Primärvorgang, der an das biologische Objekt gebunden ist. Durch Modellversuche bemühte sich LIECHTI, zu entscheiden, ob für den biologischen Primärprozess die chemische Zusammensetzung der lebenden Substanz oder deren Struktur massgebend verantwortlich sei. Mit dieser Fragestellung wollte er die Grundlage zum Verständnis der biologischen Sekundärreaktionen lokaler, humoraler, allgemeiner und nervöser Natur schaffen, die schon lange von den verschiedensten Seiten bearbeitet worden waren. In diesen Rahmen gehören auch seine zahlreichen Untersuchungen über Strahlenhaemolyse, die er als kolloid-osmotischen Mechanismus erklären konnte. Auch die Probleme der Sensibilisierung der lebenden Substanz haben ihn immer wieder angezogen und beschäftigt. Wir nennen als weitere Arbeit, die sich durch peinliche Exaktheit, Sorgfalt und Gewissenhaftigkeit auszeichnet, seine Studie über die angeblich krebserzeugende Wirkung von

sog. Erdstrahlen. Die grundlegende Frage lautet: »Kann nachgewiesen werden, dass ein ortsgebundenes, mit Erdstrahlen bezeichnetes Agens, dessen Existenz mit der Wünschelrute oder durch den Rutengänger erwiesen wird, auf das Teerkarzinom der weissen Maus fördernd einwirkt?» Die Experimente sind auf der ganzen Linie negativ verlaufen. Wenn auch dieses Resultat von vorne herein zu erwarten war, so bezeichnet es doch die gewissenhafte Forscherhaltung LIECHTIS, dass er den exakten Wissenschaftsbeweis erbringen wollte, um jedem schwindelhaften Aberglauben mit den ihm zur Verfügung stehenden Mitteln entgegenzutreten. ADOLF LIECHTI war überall ein vorsichtiger, der Grenzen der Röntgenmethode sich stets bewusster Diagnostiker. Sein enormes Wissen hinsichtlich der Erkennung von Leiden fasste er wenigstens auf einem Gebiete zusammen, nämlich dem der *Röntgendiagnostik der Wirbelsäule* (1944). Dieses Werk ist eine bedeutende Synthese eigener und fremder Erfahrung und gründet sich auf ausgedehnte entwicklungsgeschichtliche, vergleichend-anatomische und physiologische Studien, auf denen das grosse Gebiet der Erkrankungen und Verletzungen der menschlichen Wirbelsäule aufgebaut wird.

Dieses kurz vor dem Tode LIECHTIS erschienene Hauptwerk steht in einem tragischen Zusammenhang mit dem Leiden, das seine letzten Jahre, ja Jahrzehnte bedrängte und verdüsterte. Die gewaltige Tätigkeit des Verstorbenen als Lehrer, Forscher und Arzt wurde von einem Schwerkranken, von Schmerzen gepeinigten und zu fast ständigem Liegen verurteilten Manne vollbracht. Wohl wurde er auch in diesem Zustande zahlreicher Ehrungen teilhaft, wie er denn viele Jahre als initiativer Präsident der Schweizerischen Röntgengesellschaft amtete. Aber es ist klar, dass seinem Erscheinen in der Welt an Veranstaltungen und Kongressen mehr und mehr unerbittliche Grenzen gesetzt waren. Das bewirkte, dass im Auslande seine Erscheinung und Persönlichkeit wenig bekannt blieb, wenn auch sein wissenschaftliches Ansehen darunter nicht im Geringsten litt. Für einen Betrachter menschlicher Grösse aber bleibt das Beispiel dieses leidenden Helfers ein Gegenstand höchster Bewunderung und Dankbarkeit.

Zürich 1946.

HANS R. SCHINZ.

FROM THE DEPARTMENT OF ROENTGENOLOGY OF THE UNIVERSITY CLINIC (CHIEF: PROF. T. DALE, M. D.), THE BACTERIOLOGICAL INSTITUTE OF »KAPTEIN W. WILHELMSEN OG FRUE» (CHIEF: PROF. TH. THJØTTA, M D.), AND THE INSTITUTE OF PATHOLOGY, THE UNIVERSITY OF OSLO (P. T. CHIEF: PROF. F HARBITZ, M. D.)

ROENTGEN TREATMENT OF TUBERCULOUS INFECTED GUINEA-PIGS[1]

A Morphological Study

by

Ragnar Steinert and *Jan Cammermeyer*

Since the early days of the use of roentgen rays, experiments have been performed to study their effects on the tuberculous process. The results hereof have been rather conflicting. Several students have claimed improvement and even cure after roentgen treatment (LORDET and GENOUD 1896, BERGONIÉ and TESSIER 1898, KÜPFERLE and BACMEISTER 1913, MURPHY and ELLIS 1914, EIKEN 1919, RITTER and MOJE 1923), whereas others have observed no changes (MÜHSAM 1898, CORPER 1918, FORD 1927). — FORD concludes, after having examined 52 tuberculous guinea-pigs, half of them treated with roentgen rays, the other half serving as controls, that »the pathologist was unable to differentiate the treated and untreated animals by any morphological characteristics».

Strong objections may be raised against these experiments. Even if the technique has been very carefully described, it is not possible to determine the size of the dose used. We therefore decided to repeat the experiments on similar lines, using modern roentgen tubes and measuring instruments.

Technique

The animals stretched on their back, were irradiated at a focal-skin-distance (F.S.D.) of 50 cm, 170 K.V., 6 milli-amp., and a filter of 0.5 mm copper. The field treated measured 15 × 30 cm.

The dose was measured by means of a small condenser dosimeter which was pressed into the fur of the animals. By measuring the intensity of the dose over different areas of the surface of the animals, somewhat different values were found (Statens fysiske Kontrollaboratorium), as shown in Table 1. The diagram indicates the areas examined (Fig. 1).

[1] Submitted for publication, May 15, 1946.

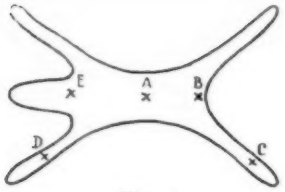

Fig. 1.

Table 1.

Dosimetry.

Areas	r min.	Min. per 100 r-units
A	24.7	4.05
B	20.5	4.88
C	16.0	6.25
D	16.2	6.16
E	23.6	4.23

As base for the experiments was used the dose measured at point A.

The animals were inoculated with human tubercle-bacilli, which previously had been dried between filter paper, weighed, ground, and mixed with saline to form a pale suspension. In the right inguinal region it was injected 0.5 cc solution, corresponding to 0.16 mg dried bacilli.

Material

For the experiment were used full-grown, healthy male guinea-pigs, each kept in a separate cage. In the following tables the individual animals are presented with their numeration under the heading of *i.i.*-group and *i.n.*-group.

Experiments

Of the tubercle infected animals, six were irradiated with a dose of 100 r., on the 9th, 11th, and 13th day after the inoculation (»infected irradiated» animals, abbr. *i.i.*). After a certain period animals of this group were killed together with one non-irradiated, but inoculated, control animal of almost the same weight seven days after infection (»infected non-irradiated» animals, abbr. *i.n.*). The period of observation and the number of animals have been compiled in Table 2.

Table 2.

Length of infection. In brackets the weight of the animals in g.

i.i.-group.	*i.n.*-group.	Days after inoc.
6 (310)	12 (290)	19
4 (410)	13 (320)	21
5 (320)	14 (340)	21
7 (430)	11 (440)	21
1 (540)	9 (510)	34
3 (490)	8 (600)	34

Necropsy of all the animals was performed and the distribution of the tuberculous changes was recorded. Specimens of tissue for microscopic examination were taken from the parts of liver, spleen, and regional lymph-nodes, showing the most heavy tuberculous changes.

Morphological Examination

For histological examination have been used the following methods: For general purpose haematoxylin-eosin stain, for collagenous connective tissue fibrils th estaining by van Gieson-method, and for argentophile fibrils the Bielschowsky-Maresch-method. The presence of iron containing pigment has been tested by the Prussian-blue method. Thionin

staining was used for the study of lymphocytes and metachromasy, and for tubercle-bacilli Ziehl-Neelsen's method.

Lymph-nodes.

In most cases the lymph-nodes in the *i.n.*-animals are slightly larger than in the *i.i.*-animals. The main part of the lymph-node has degenerated into a large, irregular, central necrosis, surrounded by a zone of epithelioid cells and scattered multinucleated giant cells. In some cases a dissemination of the process can be seen in the capsule. Within and outside this capsule there are also found cells containing moderate amounts of iron pigment and some cells showing a slight metachromasy. These reactive changes are connected with the lesion caused by the injection.

In all sections are found numerous tubercle-bacilli in and between the epithelioid cells, and a smaller number in the central necrotic region.

Comparing the course of the reaction in the two groups slight differences are observed, decreasing within the animals with the longer period of infection. The surrounding connective tissue capsule is slightly wider in *i.i.*-animals than in the *i.n.*-group.

Thin argentophile fibrils are found between the epithelioid cells. In the *i.n.*-group the network of reticulin fibres is not so distinct in the part bordering on the central necrosis. In the animals with the longest period of infection, however, the fibrils are more clearly seen. In the *i.i.*-group as a whole, development of argentophile intercellular fibres is distinct throughout the zone of epithelioid cells and the fibres are thicker than in the *i.n.*-group.

Table 3.

The width of the epithelioid zone in the lymph-nodes.

Length of infection.	*i.i.*-group.	Width μ	*i.n.*-group.	Width μ
19 days	6	—	12	187
21 »	4	133	13	107
» »	5	133	14	80
» »	7	293	11	240

The border of epithelioid cells is somewhat wider in the *i.i.*-animals than in the *i.n.*-animals. In Table 3 is indicated the width of the epithelioid zone, measured from the narrowest part.

Some scattered polymorphonuclear leucocytes are found between the epithelioid cells in the *i.n.*-animals, whereas in the *i.i.*-animals they are nearly completely absent. This difference in the occurrence of white corpuscles is still more marked in the lymphoid tissue outside the granulation tissue. The lymphocytes are greatly reduced in number and most of the nuclei are smaller and darker in the *i.i.*-group than in the controls. Between the altered lymphocytes are seen fragments of nuclei in a state of disintegration.

In both groups the central necrotic area shows mainly the same cellular picture, but in the *i.i.*-group the area appears slightly paler, because the degeneration of the nuclei is more advanced than in the non-irradiated controls. In thionin stained sections metachromasy is found in the many mast cells, in the fibroblasts of the capsule, in the wall of some blood-vessels, in and between the epithelioid cells, and in some multinucleated giant cells. This staining is more pronounced in the *i.n.*- than in the *i.i.*-group, see Table 4. On the 19th day this reaction is moderate in the *i.n.*-animal (no. 12), but already present in the *i.i.*-animal, *i.e.* metachromasy of reactive changes in the inoculated mammary gland tissue (no. 6).

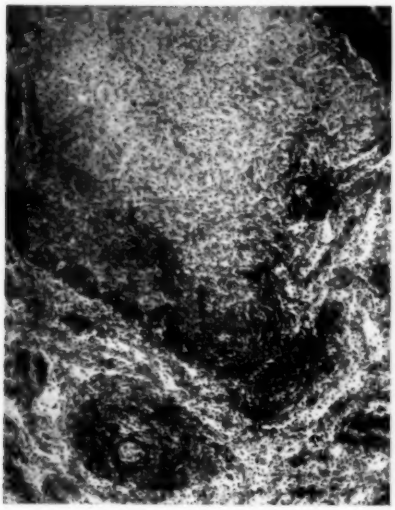

Fig. 2.

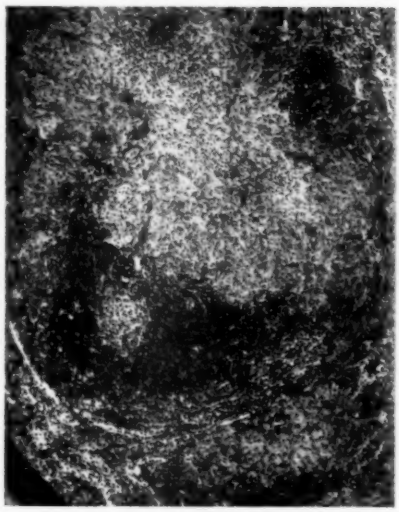

Fig. 3.

Fig. 2. Tubercle in the follicle of spleen. Transition between lymph-follicle and red pulp is sharp owing to decrease in the amount of lymphocytes in irradiated-tuberculous animal (21 days). *i.i.*-no. 4. Thionin. Magnification × 70.

Fig. 3. The same as previous fig. but the tubercle as well as the lymph-follicle contain more cells in non-irradiated animal (21 days). *n.i.*-no. 13. Thionin. Magnification × 70.

Table 4.

Metachromasy in the zone of epithelioid cells of the inoculated regional lymph-nodes.

Length of infection.	*i.i.*-group.	Mtchr.	*i.n.*-group.	Mtchr.
19 days	(6)	(+)	12	+−
21 »	4	+	13	+++
» »	5	+	14	++
» »	7	+	11	+++

Spleen.

In all the sections are found tubercles with the same distribution of bacilli, as described for the lymph-nodes. There is no difference neither in extent of the tuberculous reaction within the two experimental groups nor with regard to the histological picture. The longer the period of infection, the more advanced are the histological changes, and finally tubercles are found in all the Malpighian corpuscles.

There are, however, certain differences in the two groups. In the *i.i.*-animals the lymph-follicles are more markedly reduced, smaller and more distinctly outlined with a decidedly reduced number of lymphocytes compared to the *i.n.*-animals (compare Figs. 2 and 3). Table 5 demonstrates the difference in the size of the lymph-follicles within the two groups.

Fig. 4.

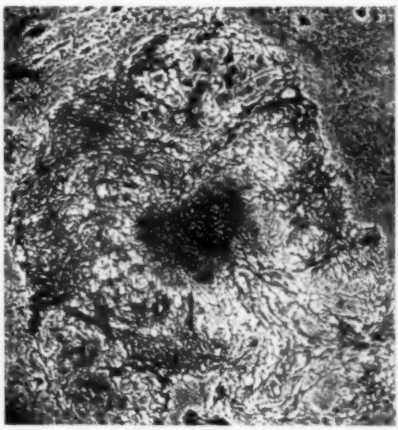

Fig. 5.

Fig. 4. Tubercle from spleen and argentophile reticulin fibrils throughout the whole zone of epithelioid cells and into the central necrotic area (21 days). *i.i.*-no. 5. Silverimpregnation after Bielschowsky-Maresch. Magnification × 70.

Fig. 5. The same as the previous fig. showing focally a lesser degree of impregnation of the reticulin fibrils (21 days). *n.i.*-no. 14. Silverimpregnation after Bielschowsky-Maresch. Magnification × 70.

Table 5.

Size of lymph-follicles in the spleen.

Length of infection.	*i.i.*-group.	Diameter μ	*i.n.*-group.	Diameter μ
19 days	6	600×262	12	646×554
21 »	4	585×354	13	1092×585
» »	5	339×323	14	615×585
» »	7	662×339	11	969×839
34 »	1	385×308	9	492×339
» »	3	431×277	8	462×323

Several changes are just as prominent in the spleen as in the regional lymph-nodes. In the *i.i.*-animals the argentophile reticular fibres are clearly seen throughout the zone of epithelioid cells of the tubercle, in contrast to animals in the *i.n.*-group (compare Figs. 4 and 5). In the former group the lymphocytes are smaller, the nuclei darker, and the central necrosis contains more pycnotic leucocytes than found in the *i.n.*-group. Also, between the epithelioid cells, a smaller number of leucocytes is seen in the *i.i.*-group than in the controls, and the whole impression obtained is that the amount of cells in the granulation tissue is least in the former group (compare Figs 6 and 7).

All the sections show a rich deposit of iron in the red pulp, most prominent in the preparations from the animals with the longest period of infection. All *i.i.*-animals show a more marked accumulation of iron pigment in the pulp of the spleen than do the non-irradiated controls (compare Figs 8 and 9). This difference is accentuated in the sections

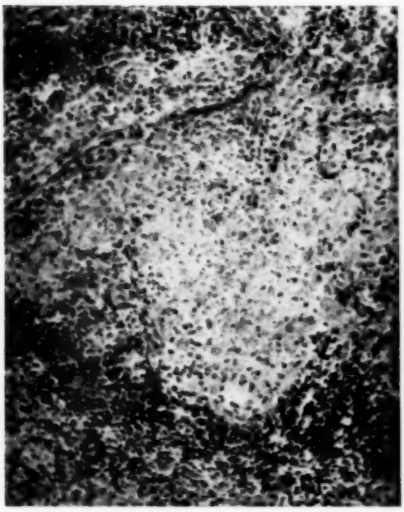

Fig. 6.

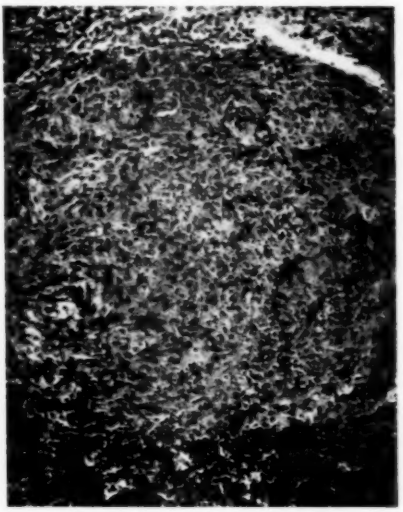

Fig. 7.

Fig. 6. Tubercle from spleen. Between the epithelioid cells are seen few scattered lymphocytes which are reduced in number within the surrounding rest of the lymph-follicles (21 days). *i.i.*-no. 5. Thionin. Magnification × 140.

Fig. 7. The same as the previous fig. showing a great number of cells between the epithelioid cells and in the surrounding rest of lymph-follicle (21 days). *n.i.*-no. 14. Thionin. Magnification × 140.

through the relative increase of the red pulp in the *i.i.*-animals, owing to the disappearance of lymphocytes and the reduction in size of the Malpighian corpuscles. The tubercles are usually centrally situated in the lymph-follicles and without iron content. None the less, parallel with the increased haemosiderosis of the sinus endothelial cells it is often found a deposit of iron in some of the tubercles, either in the whole zone of epithelioid cells or in a smaller part hereof. These findings occur mostly where the tubercles are situated closely to the red pulp. The phenomenon is more pronounced and sooner present in the *i.i*-group than in the controls (compare Table 6).

Table 6.

Prussian-blue reaction in the red pulp and tubercles of the spleen.

Length of infection.	*i.i.*-group.	Red pulp.	Tbc.	*i.n.*-group.	Red pulp.	Tbc.
19 days	6	+	—	12	+	—
21 »	4	++	+	13	+	—
» »	5	++	+	14	++	+
» »	7	+++	++	11	++	+
34 »	1	+++	++	9	++	+
» »	3	++	++	8	+	+

Fig. 8.

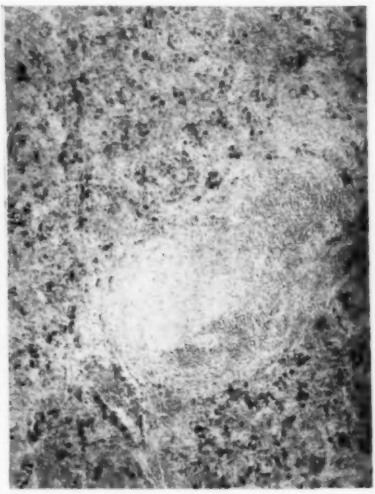

Fig. 9.

Fig. 8. Spleen with ironfree tubercles and red pulp with iron-pigment deposited in many cells and diffusively (21 days). *i.i.*-no. 7. Prussian-blue. Magnification × 42.

Fig. 9. The same as the previous fig. containing a fewer number of ironpigmented cells in the red pulp (21 days). *n.i.*-no. 11. Prussian-blue. Magnification × 42.

The metachromatic reaction of the epithelioid cells in the splenic tubercles has been examined. The results are tabulated in Table 7. Owing to the more pronounced reaction of metachromasy, the epithelioid cells in the tubercle illustrated in fig. 7 have a more greyish tone than in that of fig. 6. No conclusions can be drawn, but a further study may be of interest.

Table 7.

Metachromasy in the epithelioid cells of the splenic tubercles.

Length of infection.	*i.i.*-group.	Mtchr.	*i.n.*-group.	Mtchr.
19 days	6	++	12	+
21 »	4	+	13	++
» »	5	+	14	++
» »	7	+	11	++
34 »	1	++	9	++
» »	3	++	8	++

There is a moderate increase of the connective tissue between the sinuses of the spleen, especially in the animals who have suffered the infection for the longest period, and most marked in the *i.i.*-group.

In one of the *i.i.*-animals, which died spontaneously and therefore was not used in the present investigation, a narrow wall of fibroblasts encircling the Malpighian corpuscles

has been observed. Between the fibroblasts there were found very thin fibrils, argentophobe of character, giving only traces of the fuchsin reaction. The process of sclerosis has given to the whole preparation a lobulated appearance. This young connective tissue does not show any positive metachromatic nor amyloid reaction.

Liver.

In all sections from the liver it can be seen typical tubercles showing the usual cellular picture, as well as focal necroses of the parenchyma, some surrounded by polymorphonuclear leucocytes, others consisting only of degenerated parenchymatous cells and occasional centrally situated polymorphonuclear leucocytes. Tubercle bacilli are present but in smaller numbers than in the spleen. Generally speaking the intensity of the tuberculous changes is the same within the two experimental groups. According to the maximum and minimum diameters, typical tubercles with distinct outlines have been measured, and the values obtained are given in Table 8. In the liver, however, there is a less pronounced tendency to development of central necrosis, than in the tubercles of the spleen.

Table 8.

Size of tubercles in the liver.

Length of infection.	*i.i.*-group.	Diameters μ	*i.n.*-group.	Diameters μ
19 days	6	354×169	12	308×200
21 »	4	570×200	13	462×185
» »	5	169×139	14	615×462
» »	7	354×169	11	385×277
34 »	1	1384×354	9	723×415
» »	3	370×267	8	385×354

In the epithelioid zone there are argentophile fibres, and along the periphery scattered iron pigmented macrophages, and sometimes iron diffusely deposited over smaller and larger areas. Some of the Kupffer cells also contained haemosiderin pigments (*v.* Table 9).

The granulation tissue in the liver contains a smaller number of lymphocytes in the *i.i.*- than in the *i.n.*-animals, but the difference is not as marked as in the spleen. The metachromatic reaction of the tubercles is negative in all the animals, except in one from each group (*i.i.*-No. 1 and *i.n.*-No. 9, the latter showing slightly less reaction than the former). In the interlobular connective tissue, however, some mast cells are present, equally distributed within the two groups.

Table 9.

Prussian-blue reaction in tubercles of the liver.

Length of infection.	*i.i.*-group.	Kupf.-cells.	Tbc.	*i.n.*-group.	Kupf.-cells.	Tbc.
19 days	6	+	—	12	+	—
21 »	4	+	—	13	+	—
» »	5	+	—	14	+	—
» »	7	++	++	11	+	++
34 »	1	+	+	9	+	++
» »	3	+	+	8	+	++

Discussion of Anatomico-Pathological Findings

The morphological deviations from the normal are caused by two different agents, *viz.* the infection of tubercle bacilli and the roentgen treatment. The irradiation, besides a general effect on the organism, has a special influence on the lymphocytes.

The reaction of the lymphoid tissue to roentgen treatment is well known through the studies of LONDON (1903), HEINEKE (1903—04), KRAUSE and ZIEGLER (1906/07), LACASSAGNE and LAVEDAN (1924), TZUZUKI (1926), AKAIWA and MITSUZO (1930), a. o. (v. PENDERGRASS and HODES 1941, LACASSAGNE and GRICOUROFF 1941). In accordance herewith tubercles in the irradiated animals contain a smaller number of lymphocytes than those in the non-irradiated animals. The great similarity in the number of necrotic cells in center of the tubercles, may be explained by an accumulation of these cells before the roentgen treatment has taken effect, and a consequently slower desintegration in the necrotic masses.

In the irradiated animals the fibroblasts of the lymph-node capsule have been slightly activated. The significance of the increased development of argentophile reticular fibres in this group may possibly be explained as part of a general tendency to formation of connective tissue fibrils.

The apparent increase of iron pigment formation in the spleen may partly be explained by the effect of the roentgen rays on the red blood corpuscles, as this iron pigment deposit appears earlier and is more marked in animals which have been irradiated. This development is rather questionable, as there are various conceptions of the effect of roentgen rays on the red corpuscles (LACASSAGNE and GRICOUROFF 1941).

According to the studies by MENKIN and MENKIN (1931) the tubercles of rabbits contain iron pigment which is demonstrable by the Prussian-blue reaction, if the organs are fixed 24 to 48 hours after death. The idea of the delayed fixation is to demasc the iron present and make it accessible to demonstration by the Turnbull reaction. In our series, however, the organs were fixed immediately after death of the animals.

The diffuse iron deposition in the epithelioid and multinucleated giant cells seems in the spleen to begin in the part of the tubercle which is situated close to the sinuses. The early demonstration of iron in the tubercles of the irradiated animals, is therefore hardly a simple »demascation» due to the effect of roentgen rays *in loco* on iron, which should already be present. The demonstrated effect of roentgen rays is supposed to be accomplished through blood destruction and not through a process of »demascation». The increase of iron deposits in these areas may possibly be explained by an increased permeability of the blood vessels at the

initial stage of the tubercular formation, as it is well known that hyperaemia tends to favour an increased permeability to corpuscular and colloidal matters, as demonstrated also for iron compounds, by MENKIN and MENKIN (1931). These students, after repeated injections of ferric chloride, observed an accumulation of the metal in caseous areas in lung tubercles. Experiments with vital staining, however, demonstrated a fixation of the dye within the epithelioid and multinucleated giant cells.

The epithelioid cells showed marked metachromasy. This reaction is caused by the presence of high molecular ester sulphuric acids (LISON 1935). HOLMGREN (1938—1940) and SYLVÉN (1938—1945) have under different growth conditions described metachromatic staining of the tissue, partly combined with a rich occurrence of mast cells. SYLVÉN (1941) has not been able to detect any metachromatic reaction of tubercles in human material, possibly because these tubercles were examined at a later stage than those observed in the present animal material. In the latter the period of infection is from 19 to 34 days, when the formation of granulation tissue has been lively. The metachromatic reaction was stronger in the non-irradiated animals. So far the authors do not want to express any opinion of the demonstrated phenomena because the present experiments have not been conducted according to the standards claimed by HOLMGREN (1938) as necessary for a correct estimation of the reaction.

There is no certain difference in the two series as regards the number of bacilli, the size of the tubercles, and their distribution in lymph-node, spleen, and liver. The number of experimental animals, however, is too small to form a base for statistical examination. The morphological differences described in this paper all showed a tendency to vanish in the animals that had been infected for the longest period of time. As a whole, we do not attribute any convincing effect of the roentgen ray to the tuberculous process. In the introduction to the present paper on the same subject diverging opinions, diverging probably because of different parts of the reactive changes examined, have been reviewed.

SUMMARY

The findings in the present experiments are in accordance with the observation by FORD (1927), that the roentgen rays under the conditions examined, have no influence whatsoever on the development of the tuberculous process. This conclusion, based on morphological studies, is confirmed by the clinical findings, to be reported in a paper by STEINERT.

ZUSAMMENFASSUNG

Die Ergebnisse der hier vorliegenden Versuche stimmen mit den von FORD (1927) gemachten Beobachtungen überein, dass Röntgenstrahlen unter den untersuchten Verhältnissen auf die Entwicklung des tuberkulösen Prozesses keinerlei Einfluss ausüben.

Diese auf morphologischen Studien fussende Schlussfolgerung wird durch klinische Befunde bestätigt, die von STEINERT in einer Arbeit veröffentlicht werden sollen.

RÉSUMÉ

Les constatations faites au cours des expériences présentées ici concordent avec l'observation de FORD (1927) que les Rayons Roentgen, dans ces conditions d'examen, n'ont aucune action quelconque sur le développement du processus tuberculeux. Cette conclusion, basée sur des études morphologiques, est confirmée par les constatations cliniques qui seront apportées dans un article de STEINERT.

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FROM THE DEPARTEMENT OF ROENTGENOLOGY, SERAPHIMER HOSPITAL, STOCKHOLM
(CHIEF: PROF. E. LYSHOLM)

ROENTGEN DIAGNOSIS OF ARTERIO-VENOUS ANEURYSM OF THE LUNG[1]

by

E. Lindgren

VIRCHOW distinguished between angioma cavernosum and angioma racemosum. In the latter group he placed on the one hand teleangiectasias, and on the other hand aneurysma racemosum arteriale, aneurysma racemosum venosum (varix cirsoides) and aneurysma arterio-venosum. VIRCHOW's view was shared for a long time by succeeding pathologists. Later on, a number of angiomata in the central nervous system was added. Whether really patho-anatomically defined changes exist, that allow of such a classification as VIRCHOW conceived, is to-day much in dispute. In any case, as BERGSTRAND has pointed out, the difference between certain subdivisions of aneurysma racemosum is not anatomical but physiological. Besides the above-mentioned designations, one finds in Anglo-Saxon literature other names used to describe vascular changes of the same kind: aneurysms by anastomosis, cirsoid aneurysm, pulsation angiomas, simple angiomas. The line of demarcation between real tumours and malformations is of course floating, and this applies in an especially high degree to vascular changes. From the increased experience of recent years it has become evident that many conditions formerly regarded as tumours, and consequently referred to as angiomata, have in point of fact the character of malformations.

From the point of view of practical medicine, it is possible to distinguish among vascular changes a clearly delimited group, where the essential factor is an abnormal communication between arteries and veins. Between the arterial system and the venous system the blood does not, as is normally the case, pass through a capillary net, but flows through one or several malformed branch-vessels more or less direct to the veins. In this way there arises a short-circuit, as it were, at some

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point in the circulatory system. The view advanced by REID in 1923 in »Studies on Abnormal Arteriovenous Communications» has to a great extent clarified our views on vascular malformations and their significance. He says: »In these articles, the term abnormal arterio-venous communications will be used to include arteriovenous aneurysms, cirsoid aneurysms, pulsation angiomas and simple angiomas, for I believe that there are no essential differences between them. They are all probably instances of abnormal arteriovenous communications. If they are, then the term arterio-venous aneurysm is all-embracing, for by definition it is any abnormal communication established between the arterial and venous channels.» The clinical character of these formations becomes dependent upon where in the circulatory system the pathological communication is situated, and in which organ. One has thus a priori to expect general symptoms, *i.e.* symptoms due to the circulatory change as such, and conditions arising in consequence thereof, as well as local symptoms released in the organ in which the malformation is situated. The more centrally the pathological communication is situated, the more predominant will be the general circulatory disturbances; the more peripheral it is, the less prominent will be the general symptoms of a circulatory disturbance, until they finally disappear and only a local nutritional disturbance, due to the circulatory disorder, is left. The local symptom may, moreover, be in part due to the formation assuming the character of an expanding process, and in part due to vessel ruptures with accompanying hæmorrhages. Thus in connection with the rupture of an intracranial aneurysm one gets a cerebral hæmorrhage, and in connection with the rupture of an aneurysm situated in the lung a hæmoptysis arises.

Both congenital and acquired pathological communications between arteries and veins are in the literature referred to as arterio-venous aneurysms. It seems to the author, however, that greater clarity would be attained if this designation were reserved for the congenital changes. The embryological development of the vessels makes it easy, moreover, to understand the origin and appearance of these congenital changes. The acquired pathological communications originate traumatically. If a trauma places an artery in direct communication with a vein and this communication becomes permanent, then we have what has also been called the traumatic arterio-venous aneurysm. What has happened is, that a fistula between the vessels has arisen, and it would therefore seem more appropriate if this pathological communication were referred to as an arterio-venous fistula. (In the following these names will be employed in these senses.) That these concepts should be distinguished seems justified as the effect upon the heart also appears to differ. A fistula between large vessels may lead to sudden death or to serious cardiac changes;

more peripherally situated fistulas result in gradual enlargement of the heart. This enlargement always occurs together with a dilatation of the part of the artery situated proximally to the fistula. According to HOLMAN & REID's experiment on dogs, no enlargement of the heart arises if no arterial change occurs. On the other hand, no cardiac enlargement seems to occur in connection with the arterio-venous aneurysms. BERGSTRAND reports, however, that if the aneurysm is so big that the amount of blood is increased to any degree worth mentioning, an enlargement of the heart will arise. The author has been unable to find any agreement or satisfactory explanation concerning these conditions.

Arterio-venous aneurysms are not common but have been observed in many varied locations: in the neck, in the eyelid, in the extremities and commonest of all within the skull. In the literature, on the other hand, there are only very sparse data concerning aneurysms in the lungs, and the author has not been able to find any work dealing with their roentgen diagnosis. In point of fact, only 2 cases of undisputed arterio-venous aneurysm in the lung, diagnosed intra vitam, have been met with in the literature, one described by SMITH and HORTON in 1939, where the diagnosis was made with angiography, and one described by JONES and THOMPSON in 1944. In Oslo three cases have been diagnosed by MARSTRANDER (personal communication). These four last-mentioned cases were diagnosed with planigraphy. Nowadays it is of importance that the roentgenological symptomatology in pulmonary arterio-venous aneurysm be known, as it is now possible to help these patients with operative treatment. The author has observed 3 cases, one in each of the years 1942, 1943 and 1945, and of these, 2 have been verified by operation (op. by Dr CRAFOORD).

Case 1. E. A. P. ♂, born 1912 (30 years of age). Admitted $^{21}/_{4}$ 42. Discharged $^{5}/_{6}$ 42. Gradually kyphotic at the age of 12. In 1927 treated for his back at a country hospital. A heart-disease is then also said to have been diagnosed. Had never had any real trouble with his heart, but his work as an agricultural labourer gradually became too heavy and he was advised to change his occupation. For 1 year had had trouble in the form of rather severe dyspnea and some palpitation on exertion and complained of a heavy feeling on his chest. No cough or other lung trouble. No swelling of the legs. Now tired and languid on the slightest exertion. Latterly often complained of headache.

Condition on the $^{21}/_{4}$ 42: Somewhat pale, cyanosis of the lips. No dyspnea while resting. No oedema. Very pronounced kyphosis of thoracic spine and slight right-sided scoliosis. Clubbing of the fingers. Lungs were clear. Heart: systolic thrill over the apex. Aortic pulsations in jugular notch. Pulsations in the left infraclavicular fossa. Apex beat heaving in the 4th space 9.5 cm to left of medial line. Regular rhythm 100/min. The first sound over the base and middle had a crescendo tone. Diastolic murmur maximal over the apex. Systolic murmur maximal over the apex. A systolic murmur with another character was heard out in the left flank to about scapular angle. P^2 accentuated. Blood pressure 135/70. Abdomen 0. Blood: Hb 55 %. Red blood corpuscles 4.3 mill. White 6,600.

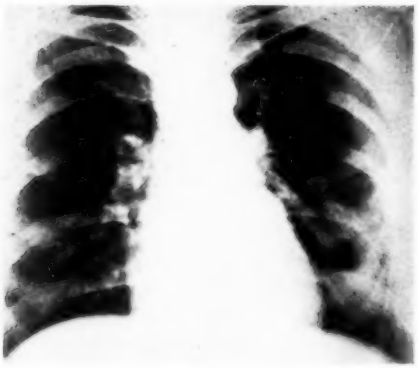

Fig. 1.

Fig. 2.

Fig. 1. Case 1.
Fig. 2. Case 1. Special picture where the vascular character of the densities is seen more distinctly.

Roentgen examination: On the left side basally there was an irregularly rounded density that was connected with broad sinuous band-shaped densities to the vessels of the hilar region. On the lateral view the change was seen to be situated at the site of the interlobar fissure between the superior and inferior lobes. On special pictures it was more clearly seen that the change was built up of broad, sinuous vessels. The roentgenological diagnosis was therefore arterio-venous aneurysm. Fluoroscopically, the aneurysm had no visible pulsations of its own. The cardiac volume was in excess of the normal variations, 530 cc per square meter of body-surface.

According to Dr BERGGREN's examination, 25—30 % of the blood passes through the arterio-venous communication.

The oxygen-content of the arterial blood on the breathing of air	12.5	vol.%
Oxygen capacity	13.9	»
Oxygen saturation	89.9	%
Oxygen tension of the arterial blood on inhalation of oxygen	123	mm
Oxygen tension of the alveolar air	670	»
	Diff. 547	mm.

A tension difference of 547 mm corresponds to a deficit of 1.66 vol. % O_2. In the case of a normal arterio-venous oxygen difference (6 vol. %) the passage of blood through the arterio-venous anastomosis amounts to 28 % of the total flow of blood through the pulmonary circulation. The arterio-venous anastomosis belongs to the pulmonary system (communication between art. pulm. and ven. pulm.).

The patient has so far not been operated upon.

Case 2. E. A. S. ♂ born 1914 (29 years old). Admitted to the Surgical Department of Sabbatsberg Hospital $^{4}/_{5}$ 43; discharged $^{2}/_{6}$ 43. The mother had teleangiectasias on the face and has sometimes suffered from nasal hæmorrhages, a brother had also sometimes nasal hæmorrhages. Since childhood the patient had had a dyspnœic tendency. Of recent years his lips have become blue as have also the fingers beneath the nails. Clubbing of the fingers. For about the past year the patient has had sudden attacks with varying symptoms: sometimes unconsciousness with convulsions, often with blindness or paralysis, the latter generally in the left arm and leg but on one occasion in the extremities of the right side. All of these symptoms soon disappear (within a period of from some hours to some days) — the paretic symptoms remain as a rule longest. On four occasions these attacks have been preceded by hæmoptysis.

Fig. 3. Case 1. Lateral view.

Examination ($^{4}/_{5}$ 43) showed slight cyanosis in face, hands and feet. No dyspnea. Covering the whole face including lips and ears were a lot of slightly raised blue-black pimples about the size of a pinhead or less (angiectasias). Clubbing of fingers and toes. Heart: Apex beat in the 5th space in the mammillar line, not heaving. Systolic murmur over the entire heart maximal on the right side of the sternum out towards the nipple. Only in the right sternal line is it possible at the same time to hear the heart sounds and observe the systolic character of the murmur. Blood-pressure 140/110. The lungs were clear. Blood: Hb 125 %, red blood corpuscles 6.18 mill. Moderately reduced strength in the left arm and leg. Tremor-like spasms in the left leg.

Roentgen examination: On the right side, below and in front of the hilus approximately corresponding to the inter-lobar fissure between the superior and middle lobes, there is an irregularly rounded formation the size of a hen's egg that through an upper and a lower broader band-shaped density (see lateral view fig. 5) is connected with the vessels of the hilar region. On the frontal picture, projecting immediately below this, there is a round formation the size of a hazel-nut, to which lead two rather sinuous vessels. These vessels are somewhat wider than the vessels in the vicinity. On the left side are seen two similar formations. On the frontal picture one of these is projected behind the heart. Here too one sees that to each of the rounded densities lead two sinuous vessels that are wider than the adjacent vessels and whose course deviates from that of the other vessels (on the reproduced picture fig. 4 A it is best seen at 3). On the performance of Valsalva's test the volume of the densities diminishes perceptibly (see fig. 6), and on the performance of Müller's test they increase in volume. The vascular character of the formations is thus clear, and here, too, the roentgenological diagnosis is

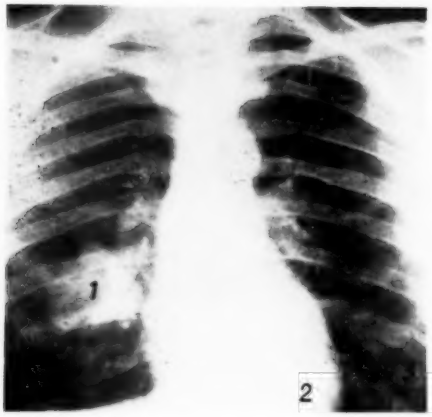

Fig. 4 A.

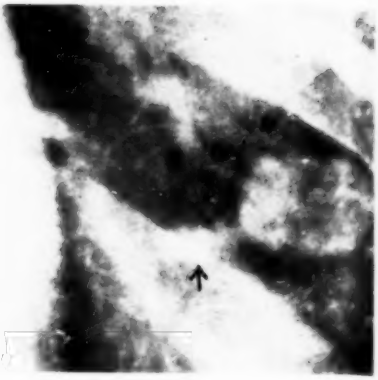

Fig. 4 B.

Fig. 4. A. Case 2. 1 the large aneurysm. Under this is seen a small one. 2 and 3 two aneurysms (2 situated behind the heart).

Fig. 4. B. Special picture of one of the small aneurysms. Note the wide vessels running to and from the aneurysm and the irregular course of these vessels (arrow).

arterio-venous aneurysm. In this case, too, it was impossible to observe any pulsations definitely emanating from the formations themselves. No cardiac enlargement. The shape of the heart is normal. An attempt at angiographic cinematography after intravenous injection of an opaque medium did not yield any diagnostically useful results.

Operation on the $^{16}/_{7}$ 43. (CRAFOORD.)

As the patient had had repeated hæmoptyses, accompanied by cerebral symptoms, which can scarcely be explained except by the occurrence of air-emboli in connection with the coughing of blood, an operation was advisable, in order, if possible, to prevent continued hæmoptyses with embolism. It had not been possible before the operation to establish clinically which side gave rise to the symptoms. As it was considered most probable that the symptoms arose from the largest of the aneurysms in the lungs visible on the roentgen picture it was decided to operate first on the right side. It was considered that it should be possible to remove the little aneurysm just beneath the large one at the same time without difficulty. In case changes should be found which during the operation might be expected to give rise to hæmorrhages which would be difficult to control, it was decided to clamp both art. and venae pulm. with hemostatic forceps before the tumours were removed and to place a compression tube around the main bronchus.

CRAFOORD's incision, with extirpation of the 7th rib. The largest aneurysm lay anteriorly in the interlobar fissure between the middle lobe and the superior lobe almost next to mediastinum. On palpating the tumour one felt a distinct continuous thrill that almost covered the entire cardiac cycle. It began early in systole and concluded late in

Fig. 5.

Fig. 6 A.

Fig. 6 B.

Fig. 5. Case 2. Lateral view.

Fig. 6. Case 2. A. Ordinary respiratory state. B. Valsalva. The size of the aneurysm then smaller.

diastole. For this reason one ought rather to have heard a continuous murmur than a systolic one, but it was evidently only the systolic phase that was perceptible to the ear through the thoracic wall. It was decided to extirpate the tumour without clamping off the large hilar formations. From the middle lobe it was possible to loosen the tumour out of the parenchymal bed it had formed for itself, and when the middle lobe was dissected out, it was seen that a branch of pulmonary vein at least the size of the little finger ran from the tumour into the hilar region of the middle lobe. It was not so easy to isolate the tumour from the superior lobe, so a resection was made of the parenchyma of the superior lobe, which was allowed to follow the tumour out. When cutting inwards towards the hilar tract, a branch of the pulmonary artery of about the thickness of a pencil was found, that plunged directly into the tumour. When these vessels had been isolated they were ligatured in towards the hilus, clamped peripherally with hemostatic forceps and divided close to the latter. It was then an easy matter to loosen the rest of the tumour together with a part of the parenchyma of the superior lobe where it was still attached near the hilar region. When the tumour had been removed it was seen that the ligatured arterial branch came from the hilar region of the superior lobe. All the incised surfaces of the parenchyma of the superior and middle lobes were sewn with one length of catgut, after which air-leakage from the lung was very insignificant. A rounded tumour of the same kind, the size of a hazel-nut, was found in the anterior lower edge of the inferior lobe, where it lay against the thoracic wall down in the sinus. A couple of resection forceps were fixed to the parenchyma of the lung just peripherally to the tumour, which was then cut away together with the attached parenchyma. Two vessels leading to the tumour and about as thick as knitting needles were ligatured, after which the incised lung surface was sewn over. Besides these two tumours the patient had a further three small aneurysms about the size of small peas superficially situated on the surface of the lung. These were, however, not considered to be of a nature calling for extirpation. Even when the lung had been allowed to empty itself of air, it was not

Fig. 7. Case 3. The aneurysm itself is partly covered by densities caused by hæmorrhage. Note the vessels to the hilus.

possible to feel anywhere any sign of further, more deeply situated tumours. Nor could any vascular malformations be observed elsewhere in the pleural cavity or in the mediastinum. The lung was therefore inflated and the thoracic wall was closed in stages by CRAFOORD's method.

Pathological anatomical examination (Prof. BERGSTRAND) showed a cystic formation almost the size of a hen's egg with relatively fresh thrombosis. The wall of the formation seems to be constituted by a malformed part of the pulmonary artery, whose elastic tissue is to a great extent malformed and in places markedly hyperplastic. Immediately outside the arterial wall is seen a relatively wide, mainly longitudinally cut branch of the pulmonary vein. This, too, shows in places circumscript hyperplasia of the elastic tissue. In one place there is a connection between the artery and the vein measuring in section about 2 mm, and through this opening the thrombus partly continues into the vein. This is probably thus a case of a thrombosed arterio-venous aneurysm. Histologically there is nothing to support the assumption of morbus Osler.

II. In the small excised portion of the lung is seen an irregularly formed blood-vessel of more arterial than venous type with a considerable splitting of the elsatic lamellae and a cushion-like thickening of the intima. This is doubtless also a case of arterio-venous anerurysm or of hemangioma racemosum. Nothing to support the assumption of morbus Osler.

Case 3. E. Ö. ♀ born in 1920 (25 years old). Admitted $^{15}/_{4}$ 45, discharged $^{16}/_{5}$ 45. In 1929, at the age of nine, under observation for suspected pulmonary tuberculosis.

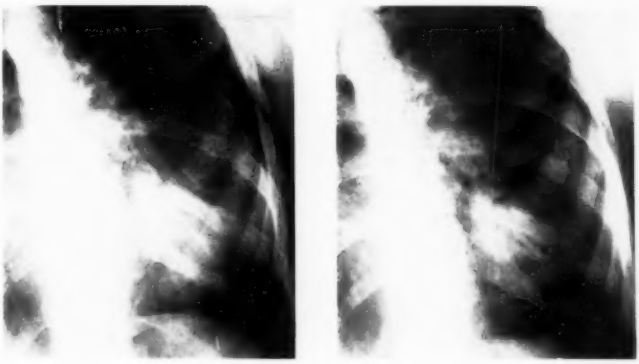

Fig. 8 A. Fig. 8 B.

Fig. 8. Case 3. A. Ordinary respiratory state. B. Valsalva.

From 1931 to 1942 troubled every spring with hæmoptysis, tiredness, loss of weight and fever. Nearly every spring in hospital or sanatorium. No definite cause of the hæmoptyses said to have been ascertained. In 1941 it was considered that the heart disease with which patient was afflicted could not give rise to the hæmoptyses from which she suffered. In 1942 lung specialists were of the opinion that the cause could not be tuberculous but must be heart disease. 0 bacilli in sputum or stomach rinsing-fluid. From the summer of 1942 no trouble until the spring 1945. Two months ago the same symptoms as earlier, *i.e.* not blood-streaked expectorations but pure blood-coloured ones, as a rule a mouthful. These have been light red, and may occur at any time. Patient increasingly tired. Poor appetite and considerable loss of weight. Temp. varying between 36.6—39°, often the same day. Short of breath on the slightest exertion. Pricking sensations at the base of the left lung on breathing. Chronic cough.

Examination on the $^{19}/_{4}$ 45: General condition unaffected. Extremely cyanotic. Clubbing of fingers and toes. No œdema of the legs. Emaciated. Heart: apex beat not distinctly palpable. No thrill. In the left flank on a level with mamilla a systolic murmur fading towards the heart. Blood pressure 125/80. Lungs were clear.

Arterial puncture after 15 minutes' respiration in 100 % O_2 gave an arterial saturation of 83.8 %, which must be considered to indicate that a hampered diffusion through the alveolar epithelium is not the cause of saturation deficit, but the cause is probably to be sought solely in shunting.

While in hospital the patient had repeated hæmoptyses.

Roentgen examination: At the left base anteriorly, roughly corresponding to the lowermost part of the superior lobe, there was an irregular density that was connected by means of broad band-shaped densities with the hilar region and that seemed at least in part to merge into the vessels of the latter. An arterio-venous aneurysm was therefore suspected, although the big density was not sharply defined. On Valsalva's and Müller's tests the volume diminishes and increases respectively. Angiocardiography was carried out in order to make the

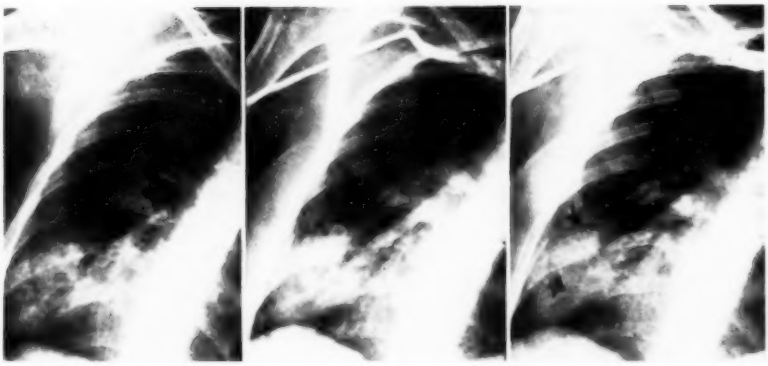

Fig. 9. Case 3. Angiography. Pictures taken at different moments. The aneurysm (arrow).

diagnosis more certain. As 70 % contrast medium could not be obtained a simultaneous injection was made in both arms of 20 ml 35 % intron (a Swedish preparation: diiodide methane sulphon acetate). On the pictures may be seen the passage of the contrast through the vessels and in the basal densities one distinguished a more dense rounded opacity joining the vessels. The diagnosis was thus an arterio-venous aneurysm.

Operation on the $^{25}/_{5}$ 45 (CRAFOORD): *Resection of the lingula lobe.*

Incision by CRAFOORD with extirpation of the 7th rib. In the spot shown by the roentgen examination a rounded mass almost the size of an orange was found in the lingula lobe, which pulsated strongly. Its external wall was very thin and one could see the whirling of the blood stream through it. The round formation had an entirely smooth surface. On the surface facing the inferior lobe interlobarly, there were 4 large bulges almost resembling the tips of fingers, which looked like large thin-walled varices. There were also some smaller similar bulges on this surface. Otherwise, both inspection of the lung and palpation of the same revealed nothing but normal conditions. On examination of the heart no changes with palpation were found. On palpation of the aneurysm, one felt a very distinct if rather faint, continuous thrill, which agreed well with the continuous murmur one imagined one could hear over the site of the aneurysm, even if this was not quite certain. Resection of that part of the lingula lobe in which the aneurysm was situated was decided upon. Resection forceps were therefore applied, the one gripping right over the medially turned edge of the lingula lobe, and applied as far in towards the hilus as possible at right angles to the edge of the lung. The other forceps gripping at right angles to the anterior edge of the lingula lobe straight across the edge of the lingula lobe facing the inferior lobe anteriorly. The forceps thus came to lie almost at right angles to each other and in towards the hilus. The aneurysm was then emptied with a syringe, and proved to contain 100 cc of blood. The peripheral part of the lingula lobe was now cut away, in which connection a 1 cm broad seam of lung tissue was left peripherally to the forceps. One could now see an efferent pulmonary vein at least as thick as the forefinger and 3 afferent arterial branches to the aneurysm. The thickest arterial branch

was more than the thickness of the little finger. The venous branch conveying blood from the aneurysm entered directly into the caudal end of the superior pulmonary vein. These 4 vessels were sewn with continuous vessel-suture. The incised lung surface was sewn over. The thoracic wall was closed in stages.

The patient's condition during the operation was very good.

After the operation the patient was examined on the $^{13}/_{6}$: The patient then had no cyanosis. The systolic murmur in the left flank had ceased.

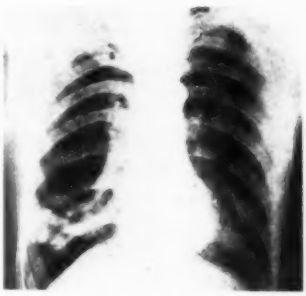

Fig. 10. SMITH and HORTON's case. A large aneurysm on the right base, a small one on the left. Note the resemblance especially to case 1.

Discussion

It is outside the scope of the present work to discuss the clinical picture in detail. It may be pointed out, however, that all three cases manifested cyanosis and clubbing of the fingers (so markedly that they were observed by the patient or by his friends). The same symptoms, indicating a serious circulatory disorder, were noticed also in SMITH & HORTON's and JONES & THOMPSON's cases. The patients easily become short of breath and in some cases have sensations of weight or of pain in the chest. 2 cases have had hæmoptyses and 1 case had attacks of short duration, which the neurologist (BROMAN) has interpreted as due to air emboli to the brain. Similar attacks seem to have occurred also in SMITH & HORTON's case, and though the latter offer no explanation they can probably be explained in the same way. Altogether, the general status of the patients is such, that one comes to think in the first place of a congenital disease of the heart.

Patho-anatomically the classical change in connection with the arterio-venous aneurysm consists of a distended afferent artery and distended efferent veins. Between the arterial and the venous systems there is either a direct communication through one or several larger vessel trunks, or a tangle of more or less distended vessels instead of capillaries. Owing to the fact that the arterial pressure is transmitted direct into the malformed vessels and into the veins, these will become increasingly dilated. Degenerative changes arise in the walls and in some cases ruptures. Through these new pathological communications may arise between the vessels, which increase the circulatory disturbance still further. Ruptures of vessels may also give rise to hæmorrhages in the surrounding areas. On the basis of this patho-anatomical appearance, the earlier described cases and the present cases observed by the author it is possible to form an idea of the roentgenology of the pulmonary arterio-venous aneurysm. Whereas in other parts of the organism we have

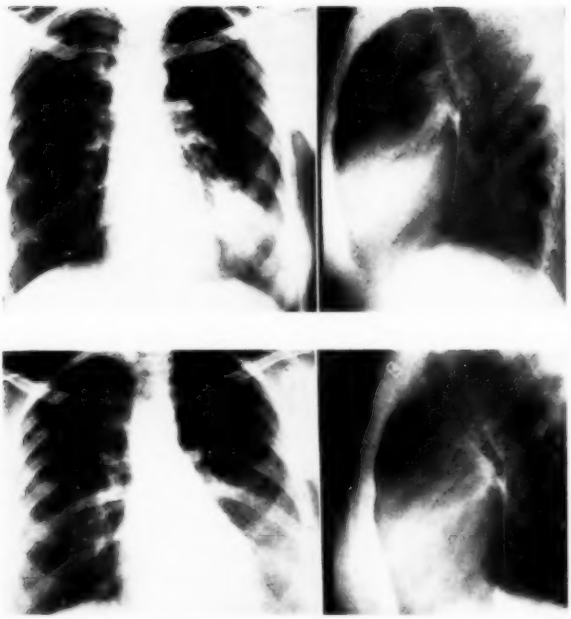

Fig. 11. Above: the appearance of the heart before the operation.
Below: the appearance of the heart five months after the operation.

only arteriography to resort to to demonstrate these changes, the conditions in the lung, thanks to the content of air, are so favourable that it is probably possible without any more complicated investigations to obtain here a correct diagnosis, at least in the majority of cases. The pictures from the cases described and from SMITH & HORTON's cases give instances of typical changes of varying extent. Common to all are the broad band-shaped densities conditioned by vessels, connected with the hilar vessels and which in the periphery communicate with one another either through more vascular formations or more rounded ones resembling tumours. The vessels lie on rather different planes, and the anatomical conditions may be seen by fluoroscopy and on pictures in various projections. The arteries are less distended than the veins. The aneurysm itself is often the most distended body of all. The larger aneurysms may to a certain extent simulate massive tumours. Their vascular communications with the hilus and their varying size according to the pressure conditions in the thorax obviate the possibility of mistake. Forced expiration with closed glottis diminishes the size: in Müller's

test (which for many patients is more difficult to perform) the size increases.

In the case of the small aneurysms, the diagnosis may be more difficult. These small changes sometimes present an appearance strongly resembling a metastasis or a cyst of some kind. Also a tuberculous process sometimes gives a ball-shaped infiltration. The variations in size may be difficult to observe, as the change is in itself only slight. The most important criterion of the nature of the change is its relation to the surrounding vessels. Even in the case of small aneurysms one sees at least two vessels in the vicinity which are broader than others situated in the same region and which are often especially conspicuous in that they have another course than other vessels and are more sinuous (see fig. 4 B). These vessels run to the pathological formation, which can thus not be separated from them. On the picture of SMITH & HORTON's case (fig. 10) one sees the aneurysm described by the authors and on the left side close to the apex of the heart a rounded opacity. The nature of this opacity is quite clear from the larger vessels running to it: also on this side there is a small aneurysm, which seems to have escaped the authors' attention. In the literature are described a number of cases of aneurysm on branches of the pulmonary artery (BARNES and STEDEM and others). These also have the appearance of round densities with a diameter of up to 2 to 3 cm. They should be distinguishable from other similar changes in that they are always connected with a vessel. The author has had no experience of such cases, but a comparison between the cases described in the literature and the small pulmonal arteriovenous aneurysms observed, shows that the former are certainly connected with a vessel, but this is not generally clearly distended, and there are in any case not two or more distended branches of vessels connected with the ball-shaped density. In the case of an inflammatory process it is theoretically conceivable that the ball-shaped infiltration may come to lie immediately by the side of the branch of a vessel so that they cannot be separated from each other. A differential diagnosis of an aneurysm on a branch of the pulmonary artery may then be impossible, but the arterio-venous aneurysm has distended vessels in its vicinity and is thus distinguishable from an infiltration.

In case 3 the roentgen picture is not so typical as in the two other cases. This patient had had repeated major and minor hæmoptyses on the days preceding the roentgen examination. In connection with vessel ruptures the blood may get into the bronchi and be coughed up, or run down into the alveoli, and the hæmorrhages may also be vented direct into the interstitial tissue. This may give rise to more irregular opacities which are more difficult to interpret. The vessel-branches forming the aneurysm may be more or less completely covered by the extravascular

blood and eventual atelectases arising therefrom. A pointer to the right understanding of the nature of the change may be obtained, however, if one only pays attention to the vessels leading from the hilus to the pathological formation. Also in such a case, Valsalva's test may yield valuable information (fig. 8). In JONES and THOMPSON's case, a small calcification is said to have been found in the aneurysm. Nothing of the kind has been observed in our cases. It is conceivable that calcifications may arise in these vascular walls just as well as in others where nutritional disorders and degenerative changes arise. According to our experience of intra-cranial aneurysms, however, calcifications in the walls of an aneurysm are rare.

In the course of the operations, pulsations deriving from the pathological formation itself have been observed. In both operated cases a thrill was felt when the aneurysm was grasped with the hand. By fluoroscopy, however, it was not possible to decide definitely whether the aneurysm had pulsations of its own and not merely transmitted pulsations. It is possible that kymographic recording of the movement may give a more definite answer to this question. JONES and THOMPSON state that in their case pulsations from the formation itself were observable fluoroscopically.

If the ordinary roentgen examination should not throw full light on a case one may have recourse to two procedures: planigraphy and angiography. If one is uncertain as to whether the band-shaped densities running to the hilus really consist of vessels or not, there is in planigraphy a method of »dissecting in vivo» and following the formation layer after layer in order to ascertain whether it merges into vessel and in this case into which vessel. Especially before an operation such an anatomical follow-up is probably of value.

Angiography, finally, gives the decisive proof. Nowadays it is probably performed everywhere according to the lines drawn up by ROBB and STEINBERG. Only a few points will be made here. The method calls for a high degree of team work and great technical precision. The chief difficulty is in getting the pictures taken at the most suitable moments. If cinematography could give sufficiently sharp pictures this method would be the best, but with the technical equipment which has so far been at our disposal this is not possible. The best pictures, at present, are obtained when some form of casette changer is employed, permitting the taking of at least 4 pictures in quick succession. TAYLOR and SHULMAN first determined the circulation time with certain drugs, and then adapted the exposures to the values thus found. A more general use of this procedure may perhaps prove to give the desirable security for the taking of the pictures. Essentially in those cases in which the aneurysm

is covered by an extravasation of blood and also perhaps by atelectasis. planigraphy and angiography are of importance for a definite diagnosis.

The two cases of arterio-venous aneurysm found in the literature have not manifested any enlargement of the heart. The author's first case has a strikingly large heart, from the clinical examination probably due to a mitral stenosis. In the two other cases there is no cardiac enlargement. In the third case, on the contrary, the heart is rather small. This third case is the only one that the author has had an opportunity of examining again after the operation. On this occasion it proved that the heart had increased in size from the volume index 500 cc, corresponding to 320 cc per sq. m of body surface to the volume index 600 cc, corresponding to 360 cc per sq. m of body surface. According to calculations about 1/4—1/3 of the amount of blood passed through the pathological communication between the arterial and venous system instead of the ordinary capillary system, which offers a totally different resistance to the blood stream. It seems to the author rather probable that before the heart has adapted itself to the new circulation conditions that have arisen through the removal of the short-circuit in the circulatory system, an increase of the rest-blood, *i.e.* an increase in the volume of the heart, must arise. The cases observed support the view expressed by REID and others, that congenital arterio-venous communications do not give rise to cardiac enlargement.

SUMMARY

The roentgenological diagnosis of pulmonary arterio-venous aneurysm is described on the basis of 2 cases in the literature and 3 cases observed by the author himself.

As a rule, a definite diagnosis is hereafter probably possible with ordinary roentgen examination, otherwise when supplemented with planigraphy or angiography.

ZUSAMMENFASSUNG

Die röntgenologische Diagnose des pulmonalen arterio-venösen Aneurysmas wird an Hand von 2 im Schrifttum wiedergegebenen und 3 von Verf. selbst beobachteten Fällen beschrieben.

Hiernach ist eine definitive Diagnose in der Regel durch gewöhnliche Röntgenuntersuchung möglich, andernfalls durch Vervollständigung mit Schichtaufnahmen oder Angiographien.

RÉSUMÉ

L'auteur donne un exposé du diagnostic radiologique de l'anévrysme artério-veineux de la pulmonaire en se basant sur 2 cas décrits dans la littérature et 3 autres observés par l'auteur lui-même.

Il en résulte que dorénavant un diagnostic exact est probablement possible, dans la règle, par l'examen ordinaire aux rayons de roentgen. A défaut, il faut compléter celui-ci par la planigraphie ou l'angiographie.

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ON THE INCIPIENT STAGES OF PORCELAIN SILICOSIS[1]

by

Preben Eskildsen and *P. Flemming Møller*

Interest in the porcelain silicosis in Denmark was awakened by GUDJONSSON's and FLEMMING MØLLER's comprehensive investigation in 1933, which disclosed the great frequency of this disease among Danish porcelain workers and started the demand for effective protection. Healthy working conditions are not only an obvious humanitarian requirement, but an important condition for the maintenance of the high technical and artistic standard of the Danish porcelain industry.

In order to control the efficacy of the improvements in the dust prophylaxis introduced in 1933, the directors of the manufactories began in 1941 an investigation with the object of determining how many years it under the new conditions takes for the silicosis to develop. The investigation is being carried out under the leadership of Prof. CARL SONNE and in close contact with the Office of Work- and Factories Inspection, represented by Dr. POUL BONNEVIE. We shall not describe here the technique and procedure employed in this investigation, our object being merely to call attention to a point of the greatest importance for the latter and for the study of silicosis in general, namely the sureness of the diagnosis. In the early stages of the disease, the diagnosis rests, of course, altogether on the roentgenologic examination; but whereas it is very easy to demonstrate a pronounced silicosis roentgenologically, the interpretation of the films when the question is of the earliest stages of the silicotic development is often very difficult. Many years' work with the subject has taught us that it requires no little experience to be able to say with some degree of certainty whether or not a roentgenograph shows incipient silicosis.

It is largely on this background that the interpretation of the roentgenographs must be considered, which in GUDJONSSON's report, referred to above, and in FLEMMING MØLLER's subsequent account of his roentgenologic studies of porcelain workers' silicosis were presented as »the earliest cases» of the disease.

[1] Submitted for publication, April 16, 1946.

That we already at that time recognised the difficulty of the early diagnostication is seen from the various designations of these cases as »possibly slight silicosis», »incipient silicosis», etc.; all, of course, vaguely hesitating expressions for the same uncertainty with regard to the true explanation of the condition observed. This uncertainty was not taken sufficiently into account in the clinical evaluation of the cases, which, in fact, should not have been set down as true instances of silicosis. In the course of years we have also become much more reserved with regard to the early diagnosis, because we realise that the transition from the normal roentgenologic picture to the first silicotic changes in many cases is so vague that it is impossible to say whether anything positively pathologic is present.

In itself this is evident, since the changes must, of course, have reached a certain degree before they find expression in the roentgenograph; but, besides, there are so many individual variations in the normal roentgenologic picture of the lung that even with a positive anamnesis it requires great experience to say whether the film before one shows anything pathologic. Many things must be considered: the patient's age, his type, the development of the musculature, the thickness of the adipose layer, the standing of the diaphragm; and to this must be added the variations in the quality of the picture which it, even with an unvarying technique, is impossible to avoid; and, finally, the unsteadiness of various kind in the picture, which it likewise is impossible entirely to escape.

In FLEMMING MOLLER's paper from 1934, the characteristic picture of porcelain workers' silicosis in the 1st stage is described as a thickening and blurring of the reticular design in the lung picture, and diminished transparency of the lung, together with a particularly strong veiling of a circumscribed area symmetrically on both sides, designated as »pseudomammae». When this is considered in conjunction with the circumstances mentioned above, which may have an influence on the appearance of the roentgenologic picture and, singly or combined, may produce changes very similar to the first silicotic ones, it will be understood that the diagnosis of the earliest stages of the disease may be extremely difficult and requires great experience, and that the diagnostic criteria mentioned must be pronounced before it can be established with certainty. The silicosis in porcelain workers is mainly of the peribronchial and perivascular type, and in the first stages there are seldom nodulous changes. If they are present, they make the diagnosis easier; but as a rule they are not seen until in the later stages, if at all.

In the first stages there are thus only the above-named changes to base one's estimate on; and as they, as said, may be vague, a certain amount of critical judgment must be exercised before the diagnosis of silicosis is pronounced. But even with the greatest caution on this point

	No.	Name	Age	Estimate 1932	Estimate 1942	Direct Comparison of the films	Occupation	Number of years engaged in the work (1942)
Group I.	1	EVM	41	slight S_2	? S	fewer changes	Glazer	25
	2	EJJ	47	slight S_2	? S	no change	Turner	24
	3	GASM	56	incip. S_2	slight S_1		Workman	14
	4	MS	67	S_2	S_{1-2}	no change	Sagger-turner	37
	5	PHSC	42	S_2	incip. S		Sagger-turner	21
	6	AaC	36	slight S_2	? S	no change	Workman	16
	7	AAH	32	? incip. S	nothing abnormal		Cleaner, etc.	17
	8	EGARA	36	? slight S	nothing abnormal		Kiln-worker	22
	9	RS-H	45	slight S_2	? S		Kiln-worker	18
	10	POFN	52	pronounced S_2	incip. S_2		Workman	22
	11	HFB	35	slight S	nothing abnormal	no change	Turner	14
	12	HIP	57	slight S_2	? S		Stone-leveller, etc.	41
Group II.	13	AHC	35	incip. S_2	S_{1-2}		Turner	21
	14	VPAB	55	slight S_2	S_{1-2}	no change	Polisher	30
	15	OJH	47	incip. S_2	S_{1-2}	no change	Polisher	22
	16	RWJ	58	S_2	incip. S_2		Turner	42
	17	SVH	46	S_2	S_2		Filter-press worker	21
	18	TVW	47	slight S_2	S_{1-2}	no change	Polisher	19
	19	LPP	60	pronounced S_2	pronounced S_2		Sagger-turner	33
	20	JAH	63	S_2	S_2		Turner	45
	21	JK	68	S_2	S_2	increased	Polisher	31
	22	GFA	31	incip. S_2	S_{1-2}	? increased	Turner	17
	23	HVEJ	53	S_2	S_2	? increased	Printer	34
	24	RVH	47	slight S_2	moderate S_2	no change	Workman	21
Group III.	25	ERO	49	? S	S_2	no change	Polisher	16
	26	EC	34	? S	S_{1-2}	? increased	Turner	19
	27	OFH	62	S_2	S_2		Sagger-turner	23
	28	HPMO	56	S_2	incip. S_2	considerably increased	Turner	41
	29	LCL	56	? S	S_1	increased	Stone-leveller	18
	30	RKK	64	S_2	severe S_2		Washery-worker	26
	31	VAH	42	slight S	S_2		Clay-cellar man	25
	32	HCMH	59	slight S_2	pronounced S_2		Sagger-turner	29
				1942	1945			
Group I.	33	HC	35	? incip. S	nothing abnormal	no change	Sagger-turner	10
	34	HCAL	43	incip. S_2	very slight S	no change	Sagger-turner	6
	35	HAM	31	S_{1-2}	nothing abnormal	no change	Filter-press worker	10
	36	OH	32	S_1	nothing abnormal	no change	Workman	9
	37	EAP	48	S_1	? slight S	no change	Packer	21
Group II.	38	SVJ	44	incip. S	incip. S	no change	Polisher, etc.	9
Group III.	39	COJ	40	S_1	S_{1-2}	no change	Paste-pulverizer	12

it cannot be avoided that sometimes an examinee will be stated to have incipient silicosis and a later examination makes it clear that the diagnosis cannot be maintained.

This uncertainty, which in Sweden has been called attention to by BRUCE, has not been the object of particular notice by Danish writers on the subject. We therefore report the following small series of investigations, which show precisely the difficulties of the early diagnosis mentioned above. The examinees were 39 young workers, who all were roentgen-examined twice. Thirty-two of them had been examined by GUDJONSSON and FLEMMING MOLLER in 1932 and were roentgenographed again in 1942; the other seven were examined at two years' interval, the last time in 1945. All the roentgen examinations were made by FLEMMING MOLLER, and the estimate on the films taken at the second examination was not primarily formed on the basis of a comparison with films, or descriptions of films, from the first.

The result of the follow-up is presented in the Table. It is to be noted that differences shown do not have any reference to the silicosis of the individual worker, but only to the estimate on the films. As the Table shows, the estimate was in 17 cases »milder», in 13 unchanged, in 9 more »serious», than at the first examination.

In five of the 17 with regard to whom the second estimate was milder (nos. 7, 8, 12, 33 and 35) there was no silicosis at all, and with regard to five others (nos. 1, 2, 6, 9 and 11) the diagnosis could not be maintained with certainty. Seven of these ten workers had in the 12 years or so between the two examinations continued at their dust-producing occupation, the other three had been at it for 2—3 years. It is worth noticing that this uncertainty in the estimation is by no means confined to the very mildest degrees of the disease; in not less than six cases (nos. 1, 2, 6, 9, 12 and 35) the original estimate of incipient 2nd degree silicosis had after study of the second film to be changed to: no, or no positive, silicosis.

A review of the roentgenologic descriptions in Group I shows that the changes on the basis of which the diagnosis was made at the first films-taking consisted chiefly in blurred or dense lung tracing, veiled transparency, and in some cases an extremely fine, minute dissemination or suggestion of spotty design; in other words, changes in the intensity of the configurations occurring in the normal roentgenologic lung picture. Actual new formations in the form of coarser streaks or larger spots were not demonstrated.

When we consider Group II, the cases in which the estimate was the same at the first and second examinations, (nos. 13, 24 and 38), we see that it comprises almost exclusively silicoses of the 2nd or incipient 2nd stages, but none of the very early forms. This cannot surprise, since the sureness of the diagnosis must be dependent on the intensity of the patho-

logic changes. The roentgenologic diagnosis in nearly all the cases in this group was based on the presence of small spots in the films.

Where the films from the two examinations could be directly compared later, there was, in these two groups, on the whole no demonstrable difference between those taken of the same individual at the first and second examinations. It was only the estimate of the film that was different. In one of the 17, the silicosis was found to have become more advanced. The comparison of the films after an estimate has been passed on those from the second examination thus clearly shows both the difficulty of the estimation and how much the greater experience helps to ensure its correctness.

Group III, where the second estimate was severer than the first, seems to have a characteristic composition. It comprises both pronounced forms of silicosis (nos. 27, 28, 30, 31 and 32), where the affection must really have become worse in the years between the first and second examinations, and milder forms (nos. 25, 26, 29 and 39). In the cases no. 25, 26 and 39, direct comparison showed no positive differences between the films taken on the two occasions. In no. 26, the silicosis should even, according to the roentgenologic description, have worsened from S? to S 1—2. Group III may therefore be supposed to contain partly silicoses that have actually become aggravated, partly cases in which the uncertainty of the diagnosis of which we have been speaking has manifested itself, only in the opposite direction from what was the case in Group I.

Though, numerically, the material here presented is not very large, it clearly shows that when the question is of porcelain silicosis, great cautiousness and reservation must be used in the diagnostication of the early stages. In this material, the diagnosis only became fully certain when the question was of silicosis in the 2nd stage, and in all probability this must be attributed to the manner in which the porcelain silicosis usually spreads, — its peribronchial-perivascular type, with gradual increase of the interstitial extension of the fibrosis and the comparatively rare combination with nodulous changes. The preceding stage: incipient S, slight S 2 or S 1—2, was at the first films-taking represented by 15 cases. In 6 of these, the diagnosis of silicosis could not be maintained with certainty at the second, although 5 of the individuals in question had continued their work in the porcelain industry for as long as twelve years.

SUMMARY

The authors present the results of an orientating study respecting the difficulty of the early diagnostication of porcelain workers' silicosis, based on an after-examination of a number of the cases which formed the material for GUDJONSSON's and FLEMMING MØLLER's investigations, in 1933 and 1934, concerning porcelain silicosis in Denmark.

The result of the present study, the object of which was to test the dependability of the early diagnosis, shows that the diagnosis can only be established with absolute certainty when the question is of silicosis in the 2nd stage.

ZUSAMMENFASSUNG

Die Verff. legen die Ergebnisse einer orientierenden Untersuchung vor über die Schwierigkeit der Frühdiagnose der Silikose der Porzellanarbeiter, und zwar an Hand einer Nachuntersuchung einer Anzahl von denjenigen Fällen, die das Material der Untersuchungen von GUDJONSSON und FLEMMING MØLLER aus den Jahren 1933 und 1934 über Porzellansilikose in Dänemark darstellten. Das Ergebnis der hier vorliegenden Arbeit, die auf eine Prüfung der Zuverlässigkeit der Frühdiagnose ausging, zeigt, dass die Diagnose nur dann mit absoluter Sicherheit gestellt werden kann, wenn es sich um Silikose zweiten Grades handelt.

RÉSUMÉ

Les auteurs apportent les résultats d'une étude concernant la difficulté du diagnostic précoce de la silicose chez les ouvriers travaillant la porcelaine; ils se basent sur les examens ultérieurs de contrôle auxquels furent soumis un certain nombre des cas qui formaient le matériel des recherches de GUDJONSSON et FLEMMING MØLLER en 1933 et 1934 sur la silicose porcelanique au Danemark. Il résulte de la présente étude, qui visait à savoir quelle confiance on peut mettre dans le diagnostic précoce, que celui-ci peut seulement être établi avec une certitude absolue lorsqu'il s'agit de silicose de second degré.

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ARTHRITIS MUTILANS[1]

(»Main et doigt en lorgnette»)

by

Børge Nielsen and *Egill Snorrason*

At times a certain form or certain stage of a disease exhibits a picture so characteristic that it receives a special term and description. If several reports appear on the subject, it may turn out that various diseases may be classified under the term, because a characteristic feature in the syndrome may occur in different diseases. In order to restore the order it is necessary either to restrict the term to the historically correct meaning, or to emphasize that the term only refers to a particularly striking feature. The writers find it most correct to restrict the term to cases of chronic polyarthritis exhibiting the marked osseous, mutilating destructions described below.

The chief advantage of knowing this syndrome is that it calls attention to the problem why certain cases show marked destruction of some bones, whereas the main rule is that destructive processes in chronic polyarthritis are slight and restricted to the extremities of the bones. Of course it is difficult to draw a sharp limit, but the typical cases prove to be so characteristic, clinically as well as roentgenologically, that there is no doubt where they belong.

It is evident from the scarce attention the syndrome receives in the text books and from the small number of cases published that this form of chronic polyarthritis is not common. The fact that the writers have been able to find 4 (6) patients referable to this group among the material from one hospital would, however, indicate that the affection can hardly be very rare.

The number of cases described in the literature has been appreciably increased by the fact that some authors have extended the limits and at the same time proposed other terms. Thus SCHÜLLER (11) in 1937 reported 6 cases of mutilating foot disease, describing them in conjunction with

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earlier reports of the disease under discussion and proposing the term arthropathia mutilans. However, all his patients were suffering from a nervous affection which caused the destructions, and only the first case exhibited a syndrome resembling the classical description. It is true that this patient suffered from polyarthritis, but he also had tabes and psoriasis, and therefore we have omitted him in our survey. JONSSON (6) realized that it was a question of different diseases and classed his second case with the group to which the above-mentioned cases belong. The reason why we have not either included JONSSON's first case is that the destructions, localized in the first metatarsal bones, were not particularly marked and not mutilating.

Perhaps, it is reasonable to include a few cases of the so-called psoriatic polyarthritis in which similar destructions are encountered (1, 12). In HEINILD's (5) material of 21 cases, none can be classed with arthritis mutilans, although it exhibited all degrees of articular changes. This author does not regard the combination of psoriasis and polyarthritis to be a proof of the existence of a special psoriatic polyarthritis. Failing, however, the final decision as to the significance of this skin disease to the occurrence of the destructions, we think these cases ought to be kept in a separate group.

Although we intend to exclude these various destructive articular affections from the group under discussion, we think it is very useful to bring them forth in relation to or in contradistinction to it, when it comes to the question of the pathogenesis of the disease. The same thing applies to similar changes which according to BRAILSFORD (2) may occur in thrombo-angitis obliterans, haematoporphyrinuria, scleroderma etc.

Below we shall briefly report 7 typical cases from the literature and add a more detailed description of 4 from among the 6 cases observed by us.

MARIE & LERI (8) published the first case in 1913 and termed it: Une variété rare de rhumatisme chronique: La main en lorgnette. The patient was a female, aged 70. Her severe, almost universally ankylosing polyarthritis had set in 28 years earlier. The changes in the hands, the source of the term, were such that the wasting of the bones allowed the finger joints to slide into each other like the sections of a telescope. The skin was thick with transverse folds, and the fingers were broad at the base, but tapering towards the tips. Therefore, the finger tips were far away from each other. Roentgen ray and anatomical findings revealed decalcification and wasting of the phalanges around the joints, and at the same time the phalanges were dislocated past each other. The feet were described as elephantine, but destructions are not mentioned.

The same authors briefly describe another case whose changes were localized in one single finger (doigt en lorgnette).

WEIGELDT (14) was the next to report a case in 1929. The patient was a female, aged 64, whose joint disease had set in 18 years earlier. During the last 4 years the disease had been relapsing, and as early as during the first weeks of this aggravation it was possible to observe an increasing shortening of the fingers. The destructions were localized around the interphalangeal joints of the fingers.

In 1935 STURSBERG (13) published two cases: A female, aged 53, who had been suffering from polyarthritis from the age of 16, exhibiting destruction of the heads of the metacarpal bones and around the metacarpophalangeal joints of the fingers. The other patient was a female, aged 45, who had had 3 attacks of rheumatic fever when she was about 20 years of age. Now she exhibited wasting of the heads of the 2nd—4th metatarsal bones and the proximal parts of the corresponding phalanges.

Lehrbuch der Röntgendiagnostik by SCHINZ, BAENSCH & FRIEDL (10) describes a female, aged 45, who had been suffering from polyarthritis for 10 years and now exhibited osteolytic processes on one foot, especially around the metatarsophalangeal joints of the 2nd—4th toes (the case is somewhat doubtful, as ulcerations are reported in the planta). Finally, in 1945 WERTHEMANN reported a case of destructions around the metatarsophalangeal joints of the toes of a male, aged 75, who had been suffering from polyarthritis for 13 years.

Writers' Cases

As mentioned above the writers' material consists of 6 cases, all encountered in women who had been suffering from polyarthritis for years. They had all, at a late stage, received sanocrysin therapy, which had not checked the disease. In two cases no roentgen examinations had been made, and they only exhibited changes in individual fingers, one in the left ring finger and the other in the middle and little fingers of the right hand. The remaining 4 cases will be described in detail:

(1) Th. L. Female, aged 43. Polyarthritis set in at the age of 26. The looseness and shortening of the fingers had been developing gradually during the last 10 years. She had not been roentgen examined earlier, but as soon as the deformity was discovered, roentgen examination was made of most joints.

The hip joints revealed nothing abnormal apart from slight decalcification. *Knee joints:* Uniform changes on both sides showing marked destruction of the cartilage and irregular ulceration of the articular surfaces. Decalcification. *Feet:* Apart from decalcification and ordinary polyarthritic changes, rather marked ulcerative processes around the metatarsophalangeal joint of the left big toe where there is tapering of the metatarsal bone. *Shoulder joints:* Decalcification and minor erosions. *Elbows:* On both sides: Marked excavation into the incisura semilunaris, flattening of the radial head and of the lower end of the humerus, so that the humeral trochlea and head seem to be absent.

Fig. 1.

On clinical examination the *hands* exhibited a typical picture apparent from Fig. 1. On account of the defects in the bones the distal parts of the fingers were loose and could be pushed into the soft parts which were ample, with transverse folds. There was not complete absence of function, as the patient was able to hold eating utensils and the like. The roentgen films (Fig. 2) show: Fusion of the carpal bones. Almost complete obliteration of the joint space in carpometacarpal joint and somewhat less marked of the radiocarpal joint. Tapered narrowing of the distal part of the ulna, the head is lacking and the changes proceed into the diaphysis. Destruction of the distal part of the metacarpal bones, so that the heads are absent. Conical atrophy of some of the metacarpal bones. Concave excavation of the bases of all the proximal phalanges. The proximal interphalangeal joints of the index, middle, ring, and little fingers of the right hand and of the index, middle, and ring fingers of the left hand exhibited destructions of the proximal as well as middle phalanges, in most of the fingers in the form of a transverse flattening, but a few of the bones are more irregular and conical. Apart from fine erosions and small defects as well as wasting of the cartilage and a rather marked decalcification, the distal interphalangeal joints reveal no destructions, and the picture differs considerably from that of the other finger joints.

Nine months later the hands were again roentgen examined. During this interval the condition of the patient had remained unchanged without a relapse. One joint, the proximal interphalangeal joint of the left ring finger, revealed perhaps some more destruction of the proximal end, but otherwise the roentgen aspect was unchanged.

Summary of the Case. Clinically both hands showed the typical »main en lorgnette» deformity, but roentgen examination revealed marked destructions around the interphalangeal and metacarpophalangeal joints of the fingers. There were marked destructive processes in the distal radio-ulnar articulation and in the elbow joints, but they were, however, on the verge of being the more ordinary polyarthritic changes. The remaining joints examined by roentgen rays only exhibited the latter

Fig. 2.

changes. There was no demonstrable progress in the destructions during a clinically quiet period of 9 months.

(2) H. N., female, aged 55, who had been suffering from polyarthritis since the age of 5. The disease had been progressing slowly during these years. From the age of 29 she had worked at sewing and still was able to do so. She was referred to the Roentgen Department on account of a breast cancer which must be considered irrelevant to the affection of the hands. Not examined by roentgen earlier. She is able to walk, but is very stiff, and only the following joints were examined:

Knees: Diffuse decalcification. Marked destruction of the cartiiage and some flattening of the articular surfaces. Moderate formation of osteophytes at the margins. Fibulae strikingly slender. *Feet:* Decalcification. Subluxations in the joints of the toes, but no destructive processes. *Shoulder joints:* Both humeral heads flattened, joint space narrow. The humeri are rather slender, but considering that the patient is extremely thin, no importance can be attached to this finding or to the thin fibulae. Rather marked decalcification. *Elbows:* Side view revealed a picture similar to the first patient, though less marked.

The aspect of the *hands* was less striking than in the first patient, but the fingers were loose in the metacarpophalangeal joints, especially of the left hand. According to the roentgen films this looseness is partly due to dislocation, and on the right side there is no distinct destruction. The deformity of this hand is therefore not typical of the syndrome. Apart from the dislocations, the left hand (Fig. 3) exhibits destruction of the metacarpal bones, most pronounced of the 5th which shows conical tapering, less of the 4th and 3rd, and on the 2nd the head is still visible. Excavations into the bases of the corresponding proximal phalanges. In the proximal interphalangeal joint of the middle finger it may be observed that the adjacent bones have made their way into each other like forks. Moreover, the structure is strikingly irregular. The carpal bones are fused on both sides, and

Fig. 3.

Fig. 4.

there is almost complete obliteration of the distal and proximal joint spaces. No particular destruction of the ulnae.

Summary of the Case. The main en lorgnette syndrome was less marked than in the first patient, and on the right hand it was due exclusively to dislocations in the metacarpophalangeal joints. On the left side, however, there was marked destruction of the metacarpophalangeal joints of the ulnar fingers.

(3) O. S—r, female, aged 56, who has been suffering from a typical progressing polyarthritis since the age of 33, especially aggravated during the last 8 years. No earlier roentgen examination of the joints. The following joints were examined:

Knees: Moderate decalcification, destruction of the cartilage, and slight flattening of the articular surfaces which show formation of osteophytes at the margins. *L. foot:* Apart from decalcification, subluxations and narrowing of the joint spaces, there are some erosions of the metatarsophalangeal joint of the big toe, but no major destructions. *R. foot* (Fig. 4): Apart from changes similar to those demonstrable on the left foot, conical atrophy of the proximal phalanges of the 1st and 5th toes. Both toes are loose and can slide out and in as described above. Osseous ankylosis of the metatarsophalangeal joint of the 1st toe. *Elbows:* No destructive changes. Clinically the *hands* only exhibit looseness of the distal interphalangeal joints of the thumbs and these joints are dislocated on the roentgen films (Fig. 5). Apart from some conical atrophy of the proximal phalanges there is no bony

Fig. 5.

Fig. 6.

Fig. 7.

destruction. The other metacarpophalangeal joints too only exhibited subluxations and dislocations, but no destruction as in the cases described above. It will, however, be observed that slightly distal to the base of the proximal phalanx of the right ring finger and more distinct on the corresponding sites on the left middle and ring fingers there are smooth rounded excavations on one side of the bones, which exhibit a greatly decreased width. On the roentgen films the heads of the ulnar metacarpal bones appear to fit into these excavations. Otherwise the films reveal the more ordinary polyarthritic changes, *e.g.* fusion of the carpal bones, but without major destructions. It is striking to see the marked decalcification and effaced structure of the substantia spongiosa.

Like the first patient this one was examined after the lapse of 9 months during which period her clinical condition had remained unchanged. The object of this re-examination was to find out whether there had been an increase in the excavations on the proximal portions of the proximal phalanges, but the picture was unchanged.

Summary of the Case. Typical destructive changes were only demonstrable on the proximal phalanges of the 1st and 5th toes on the right foot. Unilateral excavations on a few of the proximal phalanges of the fingers might, however, indicate an active destruction. No progress was, however, demonstrable after a follow-up during a quiet period of 9 months.

(4) O. S—ll, female, aged 48, who had been suffering from and been totally disabled by polyarthritis since the age of 35. The following joints were roentgen examined:

Elbows revealed decalcification and narrowing of the joint space, but no major bony destructions.

On clinical examination the *hands* chiefly showed ordinary polyarthritic changes, but there was a typical »doigt en lorgnette» deformity of both little fingers (Fig. 6). The roentgen film (Fig. 7) also exhibited conical atrophy of the 1st and 2nd phalanges of the

little fingers. The pointed ends of these phalanges turned against each other. In addition, there is marked, spotty decalcification and rather marked destruction of the distal end of the ulna, apart from the more ordinary polyarthritic changes.

Summary of the Case: Typical »doigt en lorgnette» deformity of both little fingers.

Discussion

Including the above-mentioned cases reports exist of some ten cases exhibiting striking destructive osseous processes encountered in the late stages of polyarthritis. In all the cases these processes were localized in the metacarpo-phalangeal (resp. metatarso-phalangeal) and proximal interphalangeal joints of the fingers and toes, whereas major destructions have never been demonstrable in the distal interphalangeal joints. A few patients have exhibited more marked destructions than normally encountered in a few other joints, but otherwise the roentgen films have failed to reveal changes out of the ordinary. In addition, the changes often have their sites in individual fingers or toes and are not demonstrable in the adjoining bones.

Other common features have not been found. As far as the sex incidence is concerned, most of the cases have been females, but this is not at all surprising in view of the female predominance in polyarthritis and the small number of cases. The age should, no doubt, be considered in relation to the fact that the changes are always met with in patients who have been suffering from their disease for years. As to the clinical picture, neither our material nor the cases reported in the literature revealed special features nor complicating affections which might give a hint of the origin of the destructions. Let it be mentioned in this connexion that no signs have been found of nervous diseases, and none of the patients suffered from psoriasis. An enhanced sedimentation rate and mild anaemia have been reported in several cases and were also demonstrable in our material. But on the whole laboratory investigations, *e.g.* into the calcium and phosphorus metabolism, do not appear to have been made.

Regrettably none of the patients has been followed up roentgenologically for any length of time, and therefore we cannot say how and at what rate the destructions have taken place. The two cases who were re-examined after the lapse of 9 months seem to indicate that it is — at any rate periodically — a question of a stationary or extremely slowly progressing process. The histories obtained from our patients appear to indicate a slow progress, whereas in WEIGELDT's case the shortening of the fingers seems to have taken place rapidly.

As described above the destructive processes are localized in certain particular joints, and apart from these destructions the disease does not

differ from ordinary polyarthritis. Therefore, it is reasonable to seek the cause of these particular changes in local conditions, and one might hope to find it by histo-pathological examinations. The main changes reported by MARIE & LERI are as follows: Severe fatty degeneration of the bone and neighbouring tissues. The spongy bone had disappeared and the compact bone was quite thin. Between the bone ends there was granulation tissue holding in places fragments of bony tissue. The presence of the granulation tissue led these authors to believe that it was a question of an inflammatory process. WERTHEMANN describes a similar fatty degeneration and emphasizes that he only has found signs of osteoclastic destruction in a few places. He does not mention granulation tissue, but slight pannus formation in the proximal interphalangeal joint (which, however, does not show particular destructive processes). This picture differs considerably from that described by REINHARD (9) in SCHÜLLER's 6th case which is said to resemble osteitis fibrosa. It is, however, also different from the picture described in cases of ordinary polyarthritis which does not exhibit such a fatty degeneration, but reveals fibrous degeneration of the bone marrow, wasting of the cancellous bone, and accumulation of lymphocytes and plasma cells at early as well as late stages. One author (3) has, however, mentioned destruction of the articular cartilage and the epiphysis by granulation tissue making its way from the bone marrow, and this description seems to fit MARIE & LERI's case. In addition, it is possible that the fatty degeneration is secondary, due to the long duration of the disease and the inactivity, so perhaps there is no fundamental difference between the two groups as far as histological aspect and development are concerned.

Quite slight changes in the arteries are described in both cases, but they can hardly be attributed with any causal significance. The vascular changes demonstrated by WERTHEMANN in the nail beds are probably of more interest in connexion with changes in the peripheral circulation encountered in persons suffering from polyarthritis (4) than with the question regarding the cause of the destructions. Let it be mentioned also, that MARIE & LERI observe that the nerves were intact. During recent years the problem of the significance of the nervous system to the development of polyarthritis has been resumed by the findings of LEICHENTRITT and FREUND of paraneuritic nodules (7).

Some elements of the picture might indicate the contribution of a mechanical element in the destructions, *e.g.* the bony changes in our patients Nos. 2 and 3. This cannot, however, be the primary cause, and no information was obtained to the effect that these patients should differ from others in their movements of the finger joints.

At the present it is therefore impossible to give an exhaustive explanation of the reason why these patients develop the destructions, but

perhaps further information is obtainable from more histological examinations and especially investigations into the clinical and roentgenological development. For this reason we are of opinion that it is correct to maintain the syndrome as a separate unity, although we do not think there is a sharp limit or difference in kind between these mutilating forms and the great majority of cases of polyarthritis.

SUMMARY

The writers report 4 new cases of arthritis mutilans (»main et doigt en lorgnette»), encountered in patients with polyarthritis of long standing, and discuss the cause of the destructions.

ZUSAMMENFASSUNG

Die Verff. berichten über 4 neue Fälle von Arthritis mutilans (»main et doigt en lorgnette»), die bei Kranken mit langdauernder Polyarthritis gefunden wurden, und besprechen die Ursache der Zerstörungen.

RÉSUMÉ

Les auteurs relatent 4 nouveaux cas d'arthrite mutilante (»main et doigt en lorgnette») rencontrés chez des malades atteints de polyarthrite de longue durée, et discutent des causes de ces destructions.

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PYELOSCOPY[1]

An Evaluation of the Method

by

Hans Salinger and *Fritz Saalberg*

1. Introduction

Both the intravenous and the retrograde pyelography in spite of having been improved since their introduction still give unsatisfactory results in certain cases leaving both morphologic and dynamic facts undiscovered; this is due to limitations inherent to the method and not to faulty technique.

To overcome such unavoidable shortcomings a variety of supplementary methods have been devised:

a) *for improved morphologic demonstration* by means of
   1) an additional contrast medium (O_2 or air) inside or outside the kidney:
      pneumo-pyelography (VON LICHTENBERG (22));
      artificial perirenal emphysema (ROSENSTEIN (37), CARELLI and SORDELLI (6));
      pneumoperitoneum (PARTSCH (32));
   2) stereoscopy (TESCHENDORF (42)).
   3) lateral pyelography (MERTZ (26), SHIFFLET (38)).
   4) radiography during the various phases of respiration: respiratory pyelography (BACON (1), HILDENFELD (12)).
   5) radiography in different directions and positions (PENDERGRASS (33)).

b) *for improved demonstration of functional mechanism* by means of
   1) fixation of several phases:
      serial pyelography (MOORE (27));
      kinemato-pyelography (JARRE and CUMMING (16)).
   2) kymography (MAINTZ, MEESE and WUELLENWEBER (23)).

c) *pyeloscopy:* This is a combination of fluoroscopy with serial exposures. Both purposes, a) and b) are achieved by it.

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It is the object of this paper to show that pyeloscopy by itself is a complete radiological examination of the urinary tract and in the majority of cases makes unnecessary most of the methods enumerated above. It has also the advantage of being a simple procedure and does not involve the risks connected with some of the »accessory methods», several of which have become indispensable for the diagnosis of certain affections.

2. Historical Remarks

Pyeloscopy was first described by MANGES (24) in 1911. It was further developed by LEGUEU (21) and his co-workers between 1920 and 1930. Studies of the dynamics of the calyx-pelvis-ureter by means of pyeloscopy were carried out with great success by numerous authors: LEGUEU (21), SCHMIDT (40), TRUCHOT (43), JONA (18), JONA and FLECKER (17), HERBST and MARIO (11), NARATH (31) et al. The method was also used advantageously by: MORO (28), DOSSOT (7), KAMNICKER (19), FEY (8), PLAGGEMEYER and WELTMANN (34), further by: RINTELEN (36), SIMONSOHN and LSOWSKAJA (39), HERBST (10), GONZALES (9), SCHUETZE (41), BELL, HEUBLEIN and HAMMER (3). HRYNTSCHAK (13) emphasizes the value of screening for observation of the ureter. Pyeloscopy was used by LEB (20) and MOTZ (30) to reveal anatomical lesions too small to be demonstrated morphologically, but recognizable by local function-disturbance. Pyeloscopy has further been successfully used in combination with intravenous urography by PREVÔT (35).

In spite of these numerous favourable opinions BOEMINGHAUS (4) deems pyeloscopy inaccurate and maintains that diagnosis and therapy are, apart from a few rare exceptions, effected without the help of pyeloscopy. He further points out that the amount of work involved is out of proportion to practical results.

BOEMINGHAUS's view is an exception. It is, therefore, all the more surprising that the method has not found its way into general urological roentgen-diagnosis. Thus, JACHES and SUSSMANN (15) 1941 — point out that pyeloscopy is not employed routinely in U.S.A. The illustrations in European textbooks and roentgen atlases are equally negative. It seems, therefore, justified to give an account of our experience with the method of pyeloscopy, in the study of which the one of us (SALINGER) has been engaged since 1931.

3. Technique

The patient is prepared as for the ordinary urography. The apparatus consists in an adjustable fluoroscopic stand equipped with a device for serial exposures (for so called »spot» films) — size 9×12 cm. Although this

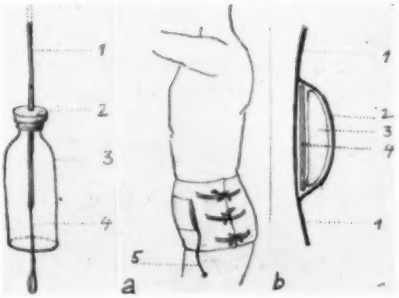

Fig. 1. Protection for the tip of the catheter. 1: catheter. 2: rubber cap. 3:glass tube. 4: stylet.

Fig. 2. Compression-belt for intravenous pyeloscopy. 1: belt. 2: bag. 3: blood-pressure cuff, pumped up. 4: wooden board. 5: rubber tube.

Fig. 1. Fig. 2.

size is by no means ideal and may, if there is ectasia of the organs, prove too small — in which case 13 × 18 cm would be preferable — we have not so far encountered any serious difficulty.

Spot films are taken in the same manner as in gastro-intestinal radiography.

The cystoscope is left in position up to the very start of the fluoroscopic examination, so that, if necessary, the catheter can be advanced farther. It should, however, be withdrawn during the examination itself since its presence would hamper the movement of the patient. We are usually employing opaque ureteric catheters and have no experience with other types *e.g.* that devised by CHAVASSU (5). Handling a catheter in the dark might involve a greater risk of an ascending infection which we try to prevent by a special device: the distal end of the catheter is introduced through a rubber membrane into a sterile piece of glass-tube the opposite end of which is closed, until injection, by a rubber stopper.

Recently for pyeloscopic studies in connection with excretion urography we are employing a modification of the pneumatic ureter-compression method of ZIEGLER (44), as modified by us for this special purpose, which does not interfere with the mobility of the patient. A belt of 20 cms width, equipped with a pocket to insert a thin wooden board and a sphygmomanometer-cuff is applied over the hypogastrium (Fig. 2). Only after the first exposures have been made, is ureteric compression applied by inflating the cuff to 80—110 mm Hg or occasionally even higher *e.g.* if the abdominal muscles are exceptionally well developed. After the morphological details of the calyces and the kidney-pelvis have been studied, the cuff is deflated and now the ureters and the degree of their fixation can be examined.

The technique we are using is that devised by MANGES and worked out by other authors. The three phases studied are: (a) the stage of filling;

(b) the morphologic details when filling is complete; (c) the stage of emptying.

As a result of our experience, it seems worth while to give a detailed account of every one of these stages.

a) The study of the phase of filling.

To begin with the tip of the catheter should lie in the kidney-pelvis, slightly above the uretero-pelvic juncture. In order to avoid irritation which may cause hyperkinesis or reflux the catheter should not be advanced as far as the calyces; but on the other hand, if the catheter is not sufficiently advanced, the calyces and pelvis may remain incompletely filled. As soon as they have been adequately filled the catheter is withdrawn until its tip lies at the approximate level of the vertebra L_4—L_5, that is just above the linea innominata pelvis. Only then do we proceed with filling of the ureter. Since, under pathological conditions, the ureter may show a tendency to hyperkinesis and spasm, perfect filling may on occasions only be achieved by injecting the contrast medium at the very moment when the catheter is being withdrawn. This applies to the ureter throughout its entire length, *i.e.* from the uretero-pelvic juncture down to the ostium; and so from the start the catheter should be passed beyond the point which is to be demonstrated.

If it is impossible to advance the catheter past the linea innominata, the smooth flow of the opaque medium may be interfered with by the pressure of the surrounding tissues. By turning the patient on his face this pressure may be effectively reduced and perfect filling achieved.

These parts of the pelvic system which offer difficulties are usually easily filled by a change of position (turning into the face, lowering the head or adopting the semi-oblique position). Occasionally the upper calyces are best filled with the patient lying supine, the lower ones with the patient lying prone. Moreover, we prefer antero-posterior exposures, a procedure by which the radiographic image becomes more distinct owing to the reduction of the distance between the film and the object.

A careful adjustment of pressure and speed of injection renders it possible to effect perfect filling of cavities without overdistending them, a purpose not to be achieved by blindly pushing the contrast medium through the catheter.

b) The study of the morphological details.

The morphology of the urinary tract is studied while rotating the patient, if necessary with further injection. Parts that were unrecognizable may become clear by turning the patient around his long axis. The fixa-

tion of the kidney and the upper part of the ureter is studied by having the patient standing nearly upright and during extreme in- and expiration. Simultaneous palpation makes it possible to establish a connection between palpatory and roentgenological findings.

c) The study of the emptying the contrast medium.

The delicate mechanism of the urine flow easily eludes attention during fluoroscopy, serial radiograms, however, furnish ample information on the functional mechanism of the urinary tract. Occasionally one observes increased peristalsis proximal to an obstruction until such is overcome. The speed of emptying is easily defined fluoroscopically. Any delay or speeding up in individual portions or in the urinary tract as a whole becomes already obvious when the contrast medium is introduced or after the catheter has been removed. Emptying should be complete at the most 15 minutes after the removal of the catheter, but usually occurs much earlier.

4. Comparison with Urography

a) *With regard to technique.*

The sore spot of both classical urographies is their being a blind procedure. In addition to this technical shortcoming the urinary system has its anatomical and functional peculiarities which more than once render such a procedure a failure.

From the detailed account of the pyeloscopic technique given in the foregoing it is quite obvious that a demonstration of the various parts of the urinary tract by the help of this method is far more promising than one by the classical urography.

b) *With regard to contrast medium.*

I) Intravenous urography: There is a disadvantage in pyeloscopy in the lack of sufficient contrast if the medium is injected i.v. This is particularly so if the concentrations of the contrast dyes we are using do not go beyond 35 per cent. With a 50 per cent. solution of Perabrodil forte we had an adverse experience: the patient, a woman, who always had normal urinary findings, after the injection developed severe cylindruria which disappeared after 3 days. Still with artificial compression as outlined above we get fairly good results in suitable cases (not obese, good kidney function).

An obstruction (calculus of the ureter, inflammatory oedema at the ostium etc.), causing enlargement of the parts just above the obstacle, automatically increases the concentration of the dye thus improving

visualization — a fact that may occasionally prove very helpful if other examination methods are impracticable.

We have no experience with contrast-increasing drugs as *e.g.* Pituitrin etc.

II) *Retrograde urography:* The risk of causing irritation of the urinary organs by the contrast media, the introduction of catheters or the unphysiologic flow, exists in the same measure for pyeloscopy as for urography. Irritation by chemical agents need no longer be taken into consideration, now that pure preparations are available. Recently we have been using Pyelodil which is usually employed in intravenous urography and have seen no adverse effect. Other preparations originally devised for intravenous urography have proved effective in pyeloscopy too, as *e.g.* Jodoxyl, Pyelectan etc. Thermic irritation is avoidable for both methods, but in contrast to urography the pyeloscopic method allows to control the speed and pressure of the injection and thus to avoid inadequate filling or complete failure to fill. The continuous observation of the filling, as a rule, saves the patient much superfluous pain and even the sensation of tension. During retrograde urography without screen control the injection is usually interrupted after the patient has reported a sensation of tension which, as is well known, may assume the character of a violent colic even after the injection has been discontinued. Usually filling is then already excessive, although occasionally it may not have taken place at all owing to spasms. The fluoroscopic observation on the contrary enables the operator to effect an adequate degree of filling before tension makes itself felt, instead of relying on the subjective impression reported by the patient.

In the following, two examples are given illustrating the advantage of filling under control of the eye over the customary filling methods.

Case No. 1. — (Fig. 3.) — (C. G., male, aged 39, No. 16384/44.)

Clinical diagnosis: splenomegaly, probably after infectious hepatitis. Differential-diagnostics had to be made from a tumour of the left kidney.

Retrograde urography (Fig. 3 a): Filling of the upper and middle calyx was satisfactory, the contours, however, irregular owing to pyelo-sinous reflux. The kidney-pelvis and the lower calyx contained but traces of the contrast medium so that there was practically no filling at all.

Pyeloscopy (Fig. 3 b): filling under fluoroscopic control showed a normal kidney pelvis and three normal sets of calyces with smooth contours and of normal size and form.

Case No. 2. — (Fig. 4.) — (E. S., female, aged 41, No. 16532/44.)

Clinical diagnosis: tuberculosis of the urinary tract; the urine contained Koch bacilli.

i.v. urography: Tuberculosis of the right kidney.

Retrograde urography undertaken with a view to eliminate involvement of the left kidney revealed pyelosinous and pyelolymphatic reflux in all calyces, a rather bizarre

Fig. 3. Case No. 1. (a) RU: Pyelo-sinous reflux in the upper and middle calyx, the lower one contains but a few traces of contrast medium. (b) PS: complete unfolding of a normal calyx-pelvis system without reflux or filling defect.

appearance of the upper calyx with irregular contours, very similar to ulcero-cavernous tuberculosis (Fig. 4 a).

Pyeloscopy (Fig. 4 b): Reflux was avoided by cautious filling and it was now cleared up that in transvesical urography only part of the upper calyx, up to the point where a subsidiary calyx branched off, had been filled while its main part had remained empty, probably owing to spasm.

Comment: Pyeloscopy showed a normal calyx-pelvis-system and no sign of tuberculosis on the left side. In both cases reflux had probably been produced by spasm after the customary filling and a filling defect had occurred, in the first case of the lower calyx, in the second of the main portion of the upper group. We were not, however, dealing with a spastic condition as it occurs *e.g.* in pyelitis. Pyeloscopy in both cases immediately followed urography and the perfect filling reached under ocular control instantly rectified the pseudopathological findings of the preceding urography.

The catheter acts as a foreign body, even if its surface is perfectly smooth. In the presence of irritability of the mucous membranes it may upset the tonus and the peristalsis which interferes with the perfect filling. This applies in the same measure to pyeloscopy as it does to urography. Since, however, these reactions are intimately connected with the position of the catheter, they are easily avoided during the screening

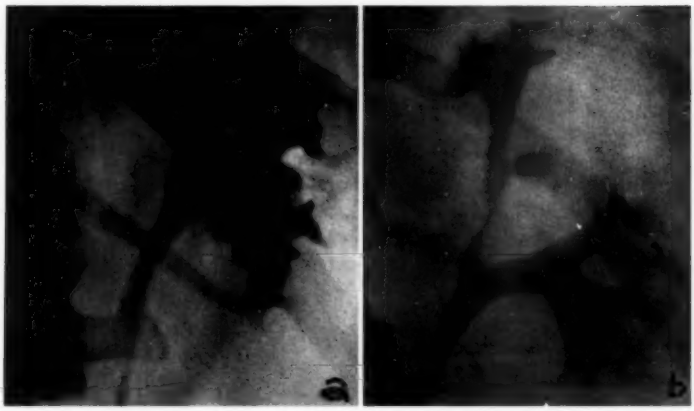

Fig. 4. Case 2. (a) RU: Pyelo-sinous and pyelo-lymphatic reflux in all calyces, the upper one being empty. (b) PS: complete unfolding of a normal pelvis and calyces without reflux or filling defect.

by changing the position of the catheter or by increasing the pressure of the injection.

Case No. 3. — (Fig. 5.) — (S. G., female, aged 27, No. 15135/43.)

Clinical diagnosis: Pyelitis on the left post partum.

A plain radiogram showed a horse-shoe kidney. There was a dense shadow, the size of an almond, on the left at the level of L_4, very laterally.

First retrograde urography (Fig. 5 a): The tip of the catheter was in the kidney-pelvis. There was moderate dilatation of several calyces and of the pelvis and marked rotation owing to the horse-shoe shape of the kidney. The catheter had passed by the shadow. Since the ureter was not filled, no information could be obtained regarding its relation to the shadow.

Second retrograde urography (Fig. 5 b): This time the tip of the catheter was at the level of the linea innominata. The kidney-pelvis and the abdominal portion of the ureter were unfilled.

Pyeloscopy: The catheter was a little withdrawn and the pressure of injection increased.

Fig. 5 c—e showed the ureter, irregularly distended and in other places constricted. Above the shadow the lumen showed a bowl-shaped distension. The shadow itself was surrounded by a narrow radiolucid edge and could therefore be identified as produced by a calculus of the ureter with severe changes of the surrounding tissues.

Operation: a stone was found surrounded by pus and blood-coagula while the wall of the ureter showed severe inflammation.

In this case the special technique of filling cleared up details not afforded by two retrograde urographic examinations.

Factors connected with Anatomy and Physiology.

Many factors may render a roentgendiagnosis extremely difficult if films are made in 2 dimensions only *e.g.*:

1) the position and the degree of rotation of the kidney,

2) the interdependence between the level the kidney is found at and the shape of the ureter, on the one hand, the position of the patient and that of his diaphragm, on the other,

3) the ramifications of the calyces in 3 dimensions,

4) the relations between the urinary tract and the other abdominal organs as well as the skeleton etc. A few examples show how these difficulties are overcome by pyeloscopy.

Demonstration of the calyces of a rotated kidney can be improved by turning the patient around the long axis of his body. This does not require any special explanation. Superposition of the ventral and dorsal row of the calyces may make the analysis of morphologic features impossible in the customary radiograms. Here one has to take resort to rotating the patient during pyeloscopy. Similarly, a previously hidden uretero-pelvic juncture may become visible by turning the patient. and a ureter lying extremely medial may emerge from the shadow of the vertebral column. Also the relations of a lime-shadow to the kidney-pelvis and the ureter may be cleared in this way.

Fig. 5. Case No. 3 (a) RU No 1: the tip of the catheter is seen in the kidney pelvis. No filling of the ureter. (b) RU No 2: the tip of the catheter is at the level of the linea innominata. Only the pelvic portion of the ureter has been filled. (c, d and e) PS: the opaque medium is seen surrounding the calculus leaving a narrow radiolucent edge while proximally there is an irregular filling defect.

Owing to the peculiar position of the kidney, particularly owing to the angle between the long axis of the kidney and that of the body, it is in certain cases important whether the patient is lying on his back or on his face.

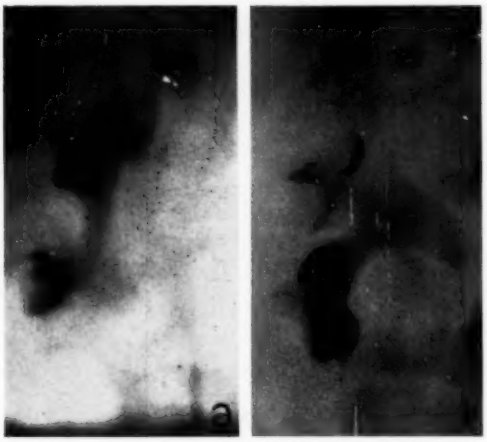

Fig. 6. Case No. 4 (a). The patient lying supine. Note filling of the upper and middle calyx; the lower one remains empty. (b) The patient lying prone: note filling of the kidney-pelvis and the lower calyces; the upper and middle one contain but traces of the contrast medium.

Case No. 4. — (Fig. 6.) — (M. M., female, aged 31, No. 20154/45.)

There was a history of abdominal pain. Renal disease had to be excluded.

Pyeloscopy revealed normal calyces, fig. 6 a: the patient lying on his back, upper and middle calyx filled, while the lower one remains empty. Fig. 6 b: the patient lying face downwards: pelvis and lower calyx filled, while the upper and middle calyx contain but traces of the contrast medium. The ureters were normal.

Comment: The lower calyx filled owing to the gravity only after it has been lowered beneath the kidney-pelvis by turning the patient on his face. That we have observed repeatedly. For the demonstration of the kidney one has occasionally to make use of the gravity, as this is customarily done for other organs. This procedure, too, is much more simple and reliable under fluoroscopic control.

The degree of fixation can be determined on fluoroscopy by observing the excursion of the kidney between inspiration and expiration. Any deviation from normal is easily recognized. The respiratory excursions cannot be expected to exceed those of the diaphragm, and absent or reduced respiratory shifting of the kidney is not to be regarded as pathological sign if movement of the diaphragm is diminished or absent. By watching the kidney when the patient gets up from a lying position we learn the degree of its static movability in relation to the vertebrae. All this is determined without additional radiograms being necessary.

The part of the ureter lying below an obstruction often offers difficulty to filling probably owing to spasm. It will be shown elsewhere how this difficulty is overcome by increasing the pressure of the injection (cf. Case No. 3) and by elevating the pelvis, moreover, by injecting while the catheter is being withdrawn (cf. Case No. 7).

Radiologists are often confronted with the question as to whether looping or kinking of the ureter may be the reason for a disturbed urine flow. To decide this with any degree of accuracy examinations have to be made in both respiratory phases, also in the recumbent position and

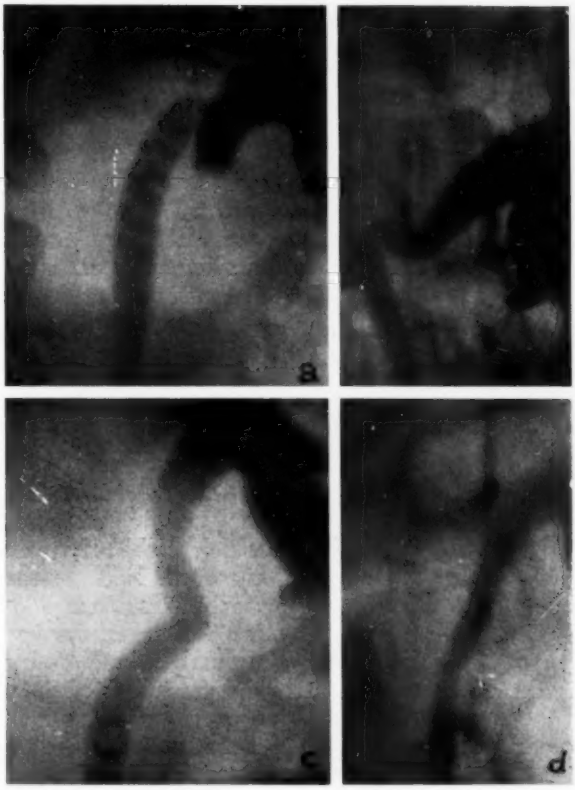

Fig. 7. Case No 5. (a) Inspiration p.a. (b) inspiration oblique. (c) expiration p.a. (d) expiration oblique.

with the patient standing upright. It is surprising how often this question is answered in the affirmative on the strength of one single radiogram showing a loop or kink without any efforts having been made to ascertain whether it is constant or only found during inspiration when the kidney is pushed downward. In the following case, *e.g.*, a hydro-mechanic disturbance could be excluded with certainty.

Case No 5. — (Fig. 7.) — (A. F., male, aged 44, No. 18109/45.)

The patient has been admitted to hospital for operation on varices pubis et regionis inguinalis. A process of the small pelvis or of the urinary tract had to be excluded.

Retrograde urography: normal calyces and kidney-pelvis; the right ureter was also normal. On the left, just below the ur.-pelv. juncture looping of the ureter appeared; otherwise there was nothing abnormal.

Fig. 8. Case No 6. (a) TV.: On the right normal filling. On the left only the pelvic part of the ureter has been filled. The kidney-pelvis and the upper part of the ureter are empty. (b) PS.: spot film during injection shows normal features.

Pyeloscopy: The ureteral loop was only present on inspiration (fig. 7 a and b) while it disappeared on extreme expiration, in upright as well as in a recumbent position (fig. 7 c and d).

Very often the question as to connection of an abdominal tumour with the kidney can be rapidly and accurately answered by palpation during fluoroscopy without the need to take radiograms.

An assumption for an undisturbed flow of urine is the elasticity of the urinary tract. Here urography can give indirect information only, but pyeloscopy yields valuable results.

The mechanism of emptying may produce urographic pictures which without a pyeloscopic check up would lead to wrong interpretation. This applies particularly to the filling defects produced by the normal sphincter-antagonism and the peristalsis of the urinary tract, a mechanism giving rise to pictures very often wrongly interpreted as »calical spasm» or »ureteral stricture». The danger of incorrect interpretation is enhanced by local increase in tonus and spasms which, in unaimed radiograms, may simulate organic filling defects and should always be carefully studied regarding their constancy.

Emptying is accelerated by hyperkinesis. It is another object of pyeloscopy to deal with this phenomenon which may involve parts or the whole urinary tract. While the urography shows no filling at all fluoroscopy reveals that the contrast medium, although entering the kidney, is instantly driven out again. If spot films are made at the very moment of filling, the radiogram obtained yields valuable information as to morphology.

Case No 6. — (Fig. 8.) — (S. C., male, aged 16, No. 16689/46.)

History: recurrent spells of fever accompanied by exsudation in several joints of an obscure nature. Renal disease has to be excluded.

Retrograde urography (fig. 8 a): on the left no pathol. findings. On the right only the pelvic part of the ureter is visible while most of the contrast medium flowed back into the bladder.

Pyeloscopy: there was immediate emptying of the contrast medium due to hyperkinesis. A spot film taken during injection (fig. 8 b) revealed normal anatomical features.

The demonstration of delayed emptying by pyeloscopy is not difficult. A delay is assumed if remnants of the opaque medium are visible still 15 minutes after the withdrawal of the catheter. We can confirm these informations found in the literature dealing with the subject.

Local disturbance of emptying in isolated calyces should be interpreted as a sign of very small local organic changes which are recognized only by this functional failure (LEB).

5. The Value of Pyeloscopy for Practical Diagnostics

In this review of cases studied in the years 1937—1945, pyeloscopy was used as an aid in urologic roentgen diagnostics with the following views:

1) to check up upon normal urographic findings which were in disagreement with the clinical picture,

2) to supplement inadequate urographic findings,

3) as a substitute for urography.

ad 1) The check-up on normal urography does not need any explanation.

ad 2) Although many cases were cleared by one or both of the urographic methods the demonstration of the urinary tract was imperfect quite often and could not be improved even by repeated urography. Here we were dealing with inadequate filling (failure to fill, incomplete or excessive filling) or with inadequacy of projection or position.

Inadequate filling may be due to normal or pathological function of the pelvis-ureter-muscles. It may, however, also be produced by morphological changes. Here the object of the supplementary examination is to ascertain whether perfect filling is possible or whether the filling defect is a constant one.

Case No 7. — (Fig. 9.) — (B. C., female, aged 25, No 18094/45.)

Clinical diagnosis: acute pyelitis on the left.

Plain radiogram: no path. findings on the right, numerous concrements on the left.

Intravenous urography: normal findings on the right. On the left excretion was insufficient, only a few of the calyces showed some filling.

First retrograde urography (fig. 9 a): the tip of the catheter was in the kidney-pelvis. There was ectasia of the calyces and the pelvis; the lower calyx contained concrements. The kidney-pelvis and the the upper part of the ureter had been got hold of in a peristaltic phase. The uretero-pelvic juncture could not be seen.

Second retrograde urography (fig. 9 b): The tip of the catheter was opposite L_4—L_5. The ureter could be filled up to its upper end at the level of the lower edge of L_2. None of the opaque medium had reached the kidney-pelvis.

Fig. 9. Case No. 7. (a) First RU: Tip of the catheter in the kidney-pelvis. Ectasia of calyces and pelvis, concrements in the lower calyx. Peristaltic phase of the pelvis and the upper part of the ureter. The uretero-pelvic juncture has not been demonstrated. (b) Second RU: The end of the catheter is opposite L 4 and L 5. The ureter has filled up to the level of the lower edge of L 2 (upper end of the ureter). No contrast-medium in the kidney-pelvis. (c) PS: Spot film during injection while the catheter is being withdrawn, the patient in Trendelenburg position. The uretero-pelvic juncture is now shown and proves to be extremely narrow. The upper portion of the ureter has »gothic-arch shape«. Congenital stenosis of uretero-pelvic juncture.

Pyeloscopy: The spot film was taken during the injection while the catheter was being withdrawn. The patient was placed in the Trendelenburg-position. In contrast to the two retrograde urographies, the uretero-pelvic juncture could now be seen (fig. 9 c) and was found to be extraordinary narrow, the ureter tapering towards the pelvis and being of gothic-arch shape. The findings were constant. There was vivid peristalsis of the kidney-pelvis.

Diagnosis: Stenosis of the uretero-pelvic juncture with secondary concrement formation, ectasia and infection.

Nephrectomy was performed (Dr. LEHMANN). *Pathologic-anatomic diagnosis* (Dr. CASPER): congenital stenosis of the uretero-pelvic juncture with ectasia of the pelvis and the calyces. No histological evidence of inflammation at the juncture. Only by means of spot radiograms the stenosis could be shown.

Case No. 8. — (Fig. 10.) — (Z. G., female, aged 25, No 8633/42.)

History: Since 1934 recurrent attacks of pyelitis on the right side. In 1936, in another hospital a plastic operation had been performed on account of stenosis of the uretero-pelvic juncture. Recovery was complicated. In 1941, there was again an attack of pyelitis with fever.

Retrograde urography (fig. 10 a): On the left side, there was nothing abnormal. On the right side, the tip of the catheter was at the height of the lumbosacral border. The kidney-pelvis was extremely distended (sac-kidney). Two attempts to fill the uretero-pelvic juncture and the ureter were unsuccessful.

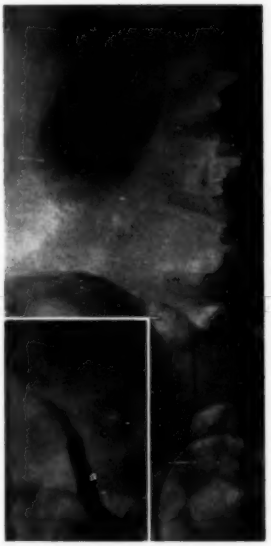

Fig. 10.

Fig. 11.

Fig. 10. Case No. 8. (a) RU: »Sack-kidney». Two attempts to fill the uretero-pelvic juncture fail. (b) PS: Spot-film taken during injection: The ureter runs laterally, enters the kidney pelvis from a lateral direction and shows gradual tapering. Rotation of the kidney by approximately 180° with torquation of ureter.

Fig. 11. Case No. 9. (a) RU: At the upper edge of the kidney pelvis an indistinctly outlined filling defect (even upon compression). (b) PS: Under increased pressure this defect can be made to disappear.

Pyeloscopy: spot films were taken during injection (fig. 10 b). The ureter is seen running to the right, opening into the kidney-pelvis from a lateral direction: it shows gradual conic narrowing. There is a rotation of the kidney by approximately 180° with torquation of the ureter.

Comment: Urographically, the demonstration of the urinary tract was very incomplete. It was the object of the pyeloscopy to make up for these shortcomings, and a stenosis at the uretero-pelvic juncture as well as a narrowing of the upper part of the ureter as a consequence of the rotation of the kidney could be shown.

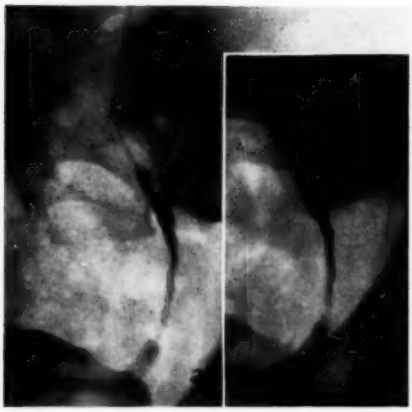

Fig. 12. Case No. 11. (a) RU: Stenosis of the lower ureteral portion starting approximately 1 cm above the ostium, showing irregular contours (»pearl-string shape»). (b) PS: spot-film taken during injection does not show any change and proves constancy of findings.

Often patients are admitted to hospital on the suspicion of organic disease of the kidney (tumour, vas aberrans etc.), a suspicion based on urographic findings (filling defects, shifting etc.). Normal filling in pyeloscopy proves the functional character of the filling defects. This renders pyeloscopy extremely useful and we call such results a »depathologisation», which means the rectification of pseudo-pathological findings, a procedure not confined to the domain of the urinary tract but being made use of in radiology in general.

Case No 9. — (Fig. 11.) — (J. F., male, aged 43, No 3706/43.)

History of recurrent colic in the left side of the abdomen with fever and haematuria. Renal disease (tumour?) had to be excluded.

Plain radiogram: without pathological findings.

Intravenous urography (performed twice) (Fig. 11 a) showed normal findings on the right. On the left, the upper calyx was long, but had sharp, straight outlines. Kidney-pelvis: in all radiograms the upper border was indistinct and showed a filling defect, even under compression.

Retrograde urography: two attempts to fill the left kidney-pelvis were unsuccessful.

Pyeloscopy: Under increased pressure the filling defect being apparent in all earlier examinations could be made to disappear (Fig. 11 b).

Comment: The negative result of pyeloscopy was confirmed by the fact, that after a follow-up period of 3 years the patient was found in perfect health. There had probably been a renal colic with expulsion of a calculus and functional disorder.

Case No. 10. — (R. S., female, aged 46, No. 19147/45.)

History: For a number of years pain in the upper abdomen, occasionally radiating to the left side of the chest and the left inguinal region. Four years before and again — five months prior to her admission to hospital — retrograde urography performed elsewhere had shown looping and consequent kinking of the ureter just below the uretero-pelvic juncture. Compression by an aberrant blood vessel was presumed. The patient was admitted for operation.

Pyeloscopy: The calyces and kidney-pelvis were normal. Looping was only apparent on extreme inspiration while on expiration both in lying and upright position, it disap-

peared completely. The rate of emptying was normal. The radiograms of this case are not added as they are essentially the same as those given in fig. 7.

Further clinical examination revealed arteriosclerotic heart disease due to coronary disease with electrocardiographic changes, also deformation of the bulbus duodeni probably as a consequence of duodenal ulcer of long standing. The pain the patient was complaining of was considered to be due to the coronary disease and treatment was instituted accordingly.

In this case pyeloscopy was instrumental in rectifying pseudopathological findings obtained by 2 urographies thus forestalling senseless surgical intervention. Other cases referred to elsewhere in this paper also show the successful rectification of pseudopathological findings.

The reverse of »depathologization» would be the confirmation of the constancy of pathological phenomena which very much adds to the accuracy of the diagnosis.

Case No. 11. — (Fig. 12.) — (S. S., male, aged 33, No. 15168/43.)

History: There was sudden pain in the inguinal region with fever.

Clinical examination: There was tenderness to percussion on the left, pyuria, leucocytosis and an accelerated blood sedimentation.

Cystoscopy: No dye excretion on the left. The ureteral catheter could not be advanced beyond 3 cm.

Retrograde urography: There was a deformated kidney-pelvis on the left; filling was irregular. Some of the contours were indistinct. The calyces did not fill. Ureter: the upper portion showed blurred contours and was partly constricted. In its lower portion (fig. 12 a) approximately one centimeter above the ostium, there was a stenosis area of several centimeters' length with irregular contours (»pearl-string shape»).

Pyeloscopy: a spot film was taken under fluoroscopic control during injection but no deviation from its original shape was noted anywhere (fig. 12 b). Pyeloscopy was able to establish the constancy of the urographic findings.

ad 3: There remains but the third object of the practical application of the pyeloscopy, viz. its use as a substitute for other methods with no preceding urographic studies.

(a) The pyeloscopy is very useful if there is no need for a complete study of the urinary tract, but only the answer to a limited question is expected, *e.g.:* to exclude a ptosis, to confirm or exclude the renal origin of a shadow seen in the region of the kidney on the plain radiogram etc.

(b) A lege-artis roentgen study of the urinary tract, particularly if PENDERGRASS' (33) postulate is to be fulfilled, needs consumption of many films. Rationing of films in war time, however, asks for extreme economizing. (Even if supplies are ample and no rationing exists this aspect of the matter will carry some weight especially if examinations have to be repeated.) Pyeloscopy, on the other hand, requires less films, as in pyeloscopy small films have to be used. Above all, a repetition is seldom necessary. At a time, therefore, when the film supply was restricted, we thought it permissible, in certain cases, to omit urography altogether and

to let pyeloscopy immediately follow upon the plain radiogram, or even to use it as the first and only measure.

6. Discussion

From the foregoing it appears that

(1) intravenous and the customary methods of retrograde urography often cannot give a definite answer and

(2) that pyeloscopy can make up for these shortcomings.

No doubt, other measures can reach this end (as *e.g.* emphasized by PENDERGRASS). Although intravenous urography as performed by PENDERGRASS supplies a maximum of information, it involves a great consumption of material (7 films, size 30×40 cm). It seems to be an established fact that by pyeloscopy the same effect is obtained but at much lower expense. More important is the fact that the method can solve the numerous special problems for which the supplementary methods have been enumerated at the outset.

HOLZKNECHT characterized the fundamental error in studying an organ-system consisting of elastic-muscular walls without screening as follows: »A radiogram of the stomach is so far from conveying the true radiological results as a picture postcard would give the impression of an excursion.» This naturally also holds true of other hollow organs which by their muscular activity are prone to change their shape constantly as *e.g.* the urinary tract (HRYNTSCHAK). The objection by BOEMINGHAUS quoted above implying that pyeloscopy is an uncertain method and that the amount of work involved is in no proportion to its results, is not justified. Among our cases there were several in which pyeloscopy was instrumental in clearing up pseudopathological findings and the patients were saved unnecessary operations. There were on the other hand cases in which diagnostic certainty was reached by proving the constancy of the pathological findings. Moreover certain changes shown by pyeloscopy would not have been perceived without screening. Such results justify the greater burden of work. For the radiologist the method, by the way, involves no greater difficulties than a complete study of the gastro-intestinal tract, usually less. Nobody would examine the gastro-intestinal tract without screening.

It is all the more surprising, therefore, that in urological roentgen practice pyeloscopy has found but little attention (cf. BAKER's (2) collective review). The dissatisfaction felt by BOEMINGHAUS, and certainly also by others who did not publish their negative experience, is probably due to technical shortcomings. Ineffective contrast media and insufficient brightness of the fluoroscopic screen have today been overcome by the

achievements of the industry. Every adjustable stand and every aiming device equipped with an effective screen can be used. MORRIS' (29) opinion that pyeloscopy has found so limited employment because of the lack in proper equipemnt does not hold true.

The risk to the roentgen worker is also reduced by the small size of the radiograms, since secondary radiation from the patient is limited by the narrowing of the primary ray cone.

Our conclusion is, therefore, that pyeloscopy is an indispensable supplementary method for retrograde urography as well as for many cases of intravenous urography, in which pyeloscopy is usually successful after ureteral compression. We would even go one step further and agree with MORRIS who, in 1932, demanded that every retrograde filling should, as a matter of routine, be performed under the control of the fluoroscopic screen.

SUMMARY

Retrograde as well as intravenous urography in a number of cases fails to give conclusive information for morphological, physiological and roentgen technical reasons, and need the support of a supplementary method. The most effective way for making up for these shortcomings is by pyeloscopy, *i.e.* a combination of fluoroscopy with the taking of spot radiograms. The main object of this method is a check-up on the position of the catheter, the optimal degree of filling, the direction of exposures, and the determination of the speed of emptying. A device is described for protection of the catheter against contamination likely to occur at work in the dark. Intravenous urography is effectively supplemented by pyeloscopy. A compression device is described which does not interfere with the mobility of the patient.

It is pointed out that intravenous urography should not be undertaken without a pyeloscopic check-up under ureteral compression on findings which are not quite clear-cut, and that retrograde filling should not be performed without fluoroscopic control.

ZUSAMMENFASSUNG

Die retrograde sowie auch die intravenöse Urographie können in einer Anzahl von Fällen aus morphologischen, physiologischen und röntgentechnischen Gründen keine Schlussfolgerungen ermöglichenden Auskünfte geben und müssen durch eine vervollständigende Methode unterstützt werden. Die effektivste Art, diese Versager wettzumachen, ist durch Pyeloskopie, d. h. eine Kombination von Fluoroskopie mit der Aufnahme von lokalen Radiogrammen. Der Hauptzweck dieser Methode ist Klarlegung der Lage des Katheters, des optimalen Füllungsgrades, der Richtung der Aufnahmen und der Bestimmung der Entleerungsgeschwindigkeit. Es wird eine Anordnung beschrieben zum Schutze des Katheters gegen Infektion, die beim Arbeiten im Dunkeln leicht eintreffen kann. Intravenöse Pyelographie wird durch Pyeloskopie effektiv vervollständigt. Es wird eine Kompressionsanordnung beschrieben, die die Beweglichkeit des Kranken nicht behindert.

Es wird betont, dass intravenöse Urographie nicht vorzunehmen ist ohne eine unter Ureterkompression vorgenommene pyeloskopische Klarlegung von nicht ganz eindeutigen Befunden, und dass retrograde Füllung nicht ohne fluoroskopische Kontrolle zur Ausführung kommen soll.

RÉSUMÉ

Tant l'urographie rétrograde que l'intraveineuse manquent, dans un certain nombre de cas, à donner des renseignements concluants, et cela pour des raisons morphologiques, physiologiques et de technique radiologique; elles ont donc besoin d'un appui supplémentaire. Le moyen le plus efficace de combler ces lacunes est le recours à la pyéloscopie, c'est-à-dire à la combinaison de l'examen à l'écran avec la prise de radiographies «dirigées». Le but principal de cette méthode est de contrôler la position de la sonde, le remplissage optimum, l'incidence sous laquelle prendre les radiographies, la vitesse d'évacuation. Description d'un arrangement pour mettre la sonde à l'abri d'une contamination, qui risque de se produire pendant le travail dans l'obscurité. L'urographie intraveineuse est avantageusement complétée par la pyéloscopie. Description d'un système de compression qui n'empêche pas de mobiliser le malade.

Les auteurs soulignent que l'urographie intraveineuse ne devrait pas être entreprise sans contrôle pyéloscopique sous compression urétérale lorsque ses résultats ne sont pas absolument nets, et qu'il ne faudrait pas pratiquer de remplissage rétrograde sans contrôle à l'écran.

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FROM THE UNIVERSITY CLINIC ROENTGEN DEPARTMENT, OSLO, NORWAY
(CHIEF: PROFESSOR TORLEIF DALE, M. D.)

VERTEBRA PLANA IN LIPOIDOSIS[1]

(HAND-SCHÜLLER-CHRISTIAN)

A contribution to the etiology of aseptic necrosis of bone

by

Johan Torgersen, M. D.

This is a report on a $3^1/_2$ year old girl, Children's Department, Oslo University Clinic, No. 6774/45. She was well until she was $2^1/_2$ years old. At that time, December 1944, she had pyelitis. A short time later she began to complain of abdominal pain, and in January 1945, her parents noticed a slight curvature in her spinal column. She was admitted into a hospital. Tuberculin tests were negative. Roentgen examination showed destruction of the 8th thoracic vertebra. This was reduced little by little to a thin disc, a typical picture of vertebra plana. While the patient was in the hospital a fluctuating swelling developed in the temporal region. The swelling contained particles which appeared to be fibrinous. No microscopic examination was performed.

Fig. 1.

She was transferred to the Children's Department, the University Clinic. Her general condition was good. There were a few bronchitic sounds in the chest. Ca. in serum 9.2 mg. %, P. 4.29 mg. %, cholesterin 167 mg. %. Slight leucocytosis, no eosinophilia. The 8th thoracic vertebra was reduced to a thin, well defined disc. No reduction of the cartilage. A circular rarefaction about 3 cm. in diameter was found in the skull. In the right lung below the clavicle there were densities in the parenchyma. (Figs. 1, 2 and 3).

I find this case to be of general interest on the basis of an article in the British Journal of Radiology by R. FAWCITT and the discussion of vertebra plana in a monograph concerning roentgen diagnostics of the spinal column by LIECHTI (1944). FAWCITT found vertebra plana in a patient with changes in other bones similar to those found in the skull in my patient. LIECHTI states that one occasionally finds other skeletal

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Fig. 2.

changes in connection with this rare disease. The possibility of lipoidosis is not mentioned by these authors.

In 1933 FRIMANN-DAHL and FORSBERG published an interesting observation in this connection. A child with Hand-Schüller-Christian's disease had multiple lesions of the skeletal system. They found the characteristic rarefactions in the skull and other bones, as well as a reduction of the 5th cervical vertebra which was similar to a vertebra plana, although it was not so typical as that of my patient. Lesions of the vertebra have since been reported several times in connection with this disease.

If the reports are compared with the roentgen picture of the vertebra, the skull defect and the lung finding in my patient, there is little doubt that this is a classic picture of vertebra plana in Hand-Schüller-Christian's disease.

Vertebra plana was first described by CALVÉ in 1925. It was for the first time demonstrated in Norway by BÜLOW-HANSEN at a meeting of the Norwegian Surgical Association in 1924. The cause of the disease is not known. SUNDT, who reports a case, reviews the previous cases and discusses the problems which arise in connection with the disease.

Similar roentgen pictures of the spine, though not the classic vertebra plana, are found in other lipoidoses, Gaucher's disease and gargoylism, in the latter combined with other psychic and physical defects.

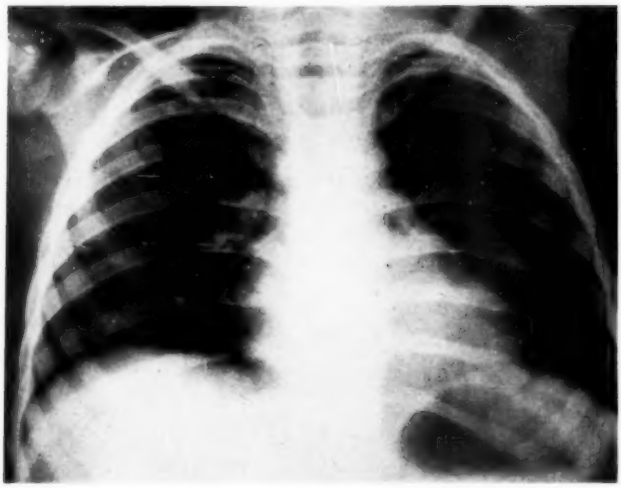

Fig. 3.

MAZZARI has described the condition in a child with congenital syphilis. The child later developed exophthalmus, and it is reasonable to suspect a Hand-Schüller-Christian's disease in this case also.

In regard to the etiology, attention has been directed particularly toward the endocrine organs. My own observations, together with those previously published, indicate that other constitutional factors such as lipoid metabolism are also important. Disturbances in the lipoid metabolism may also have an endocrine basis. On the other side the affection of the skull in Hand-Schüller-Christian, as is well known, may cause disturbances in the function of the hypophysis.

Vertebra plana has always been interpreted as an aseptic necrosis of the bone. Considering this condition, which has practical importance, in the light of the knowledge gained from these rare cases, one must include the possible effects of a combination of endocrine and metabolic disturbances in the pathogenesis of these diseases. SUNDT mentions that vertebra plana may be combined with obvious congenital anomalies of the spinal column. RIBBING found a mixture of congenital anomalies and epiphyseal disturbances resembling osseous necrosis in cases of multiple hereditary necrosis of the epiphyses. T. DALE described familial osteochondrodystrophy in a patient who was mentally defective and in another who had pathologic adipositas. Roentgen examination of the hip showed a condition between local malformation and an aseptic

necrosis of the bone, a Calvé-Legg-Perthes' disease. The patient discussed by SUNDT was mentally defective.

Here one deals with a combination of congenital malformation, endocrine disturbances, metabolic anomalies, and secondary diseases in the skeletal system. Infections may be assumed to have a releasing effect on the local affection, as in MAZZARI's case.

It would be premature to conclude that all aseptic necroses of bone are the result of constitutional conditions related to endocrine and metabolic disturbances. However, there are facts to support this view, not least the sex distribution. This may depend either on endocrine causes or other more specialized differences related to metabolism, which are not yet known, perhaps chiefly lipoid metabolism. Constitutional pathologic manifestations in the skeletal system may have their basis in the same chromosome and hormone balance which determines sexual differentiation. Heredity shows the importance of the chromosomes; the clinical picture shows the effect of the hormones. In such a rare disease as polyostotic fibrous dysplasia several instances have occurred of pubertas praecox. Personally I have observed a 7-year old girl (Children's Department, the University Clinic, No. 1082/46) with pubertas praecox and the usual dominant hereditary cartilaginous exostoses.

Recent investigations have clarified the endocrine and hereditary factors in the aseptic necroses of the bone. The simultaneous congenital anomalies are the result of physiologic developmental complications, which occur between fertilization and that point of development at which one can demonstrate hormone activity. The anomaly is a residue of the period in which the embryonic organizers were leading in development. In a few isolated cases physiological chemistry has succeeded in demonstrating the metabolic peculiarities. Many problems remain for the physiologist in this field, and they probably can best be solved in cooperation with research in heredity, endocrinology and morphologic constitutional investigations, in which roentgen examinations of the skeletal system give invaluable opportunity for study of variations, anomalies and pathologic manifestations.

SUMMARY

A case is reported of vertebra plana combined with affections in other bones, typical of Hand-Schüller-Christian's disease, with a brief discussion on the etiology of aseptic necrosis of bone.

ZUSAMMENFASSUNG

Es wird über einen Fall berichtet von Vertebra plana, kombiniert mit für die Hand-Schüller-Christian'sche Krankheit typischen Affektionen in anderen Knochen, und die Ätiologie der aseptischen Knochennekrose kurz besprochen.

RÉSUMÉ

Relation d'un cas de vertebra plana combinée avec des lésions d'autres os typiques de la maladie de Hand-Schüller-Christian, et brève discussion portant sur l'étiologie de la nécrose osseuse aseptique.

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FROM THE FINNISH RED CROSS HOSPITAL (CHIEF: A. SNELLMAN, M. D., DOCENT)

ON THE TECHNIQUE OF HIGH RETROGRADE ARTERIOGRAPHY IN CIRCULATORY DISTURBANCES OF THE LOWER LIMBS[1]

by

Matti Sulamaa

When an arterial circulatory disturbance in the lower extremities is with a greater or a lesser certainty diagnosed, the first endeavour is, before beginning the treatment, to establish to what degree the disturbance originates in organic changes and to what degree in arterial spasm, and further the extent and the location of the obstruction of blood stream. Palpation of pulse, oscillometry, and taking of the temperature of skin, together with sympathicus blocades, allow even of far-reaching conclusions, but the only means that gives differential diagnostic certainty and a clear conception of the location of the process, is arteriography (KLOSTERMEYER, in 1942, SAEGESSER, in 1946). As a practical method of investigation it has however considerable restrictions, particularly if ideal contrast medium is not disposable. It is not my intention to deal in this article with the suitability of different contrast mediums or the usual technique of the arteriography of the extremities, but to discuss, on the basis of my own observations and experience, the technique of arteriographic demonstration of changes in high pelvic arteries.

BROFELDT established in 1932 that limbs amputated for necrosis displayed almost regularly and even in younger age groups central arterial changes causing stenosis. He regarded stenosis in these cases as a primary factor in the pathogenesis of necrosis in the extremities. After I had observed, at first casually and since then very often, in patients showing symptoms of claudicatio intermittens, on the principal arteries, buzzing or whistling systolic accessoric sounds, resembling aneurysm on auscultation, I have with their guidance endeavoured to extend arteriographic examination to pelvic arteries. Evidently on account of the prevailing conceptions regarding the pathogenesis of these conditions, arteriographic research elucidating circulatory disturbances of the limbs has chiefly been directed to the periphery, in the lower limbs accordingly below the

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inguinal ligament. Even the technically difficult aortography advanced by DOS SANTOS SR., in 1931, was principally employed in examining other than arterial diseases, although the observations of BROFELDT should have given particular rise to the arteriography of the central parts of the arteries. Experiments of this kind were not undertaken until FARINAS, in 1945, injected the contrast medium from the femoral artery through an ureter catheter introduced up into the aorta, and later on used, in order to effectuate retrograde diffusion, a high pressure syringe similar to that employed by DOS SANTOS in aortography.

By injecting the contrast medium during compression of aorta, I have succeeded in effectuating good retrograde diffusion. I have been able to establish that in cases which showed above mentioned murmurs near the femoral artery, it was possible to detect stenosis or irregularities of the vessel wall in corresponding pictures of upper arteries. My technique was as follows:

1. Spinal anaesthesia. (As painless contrast mediums were not at my disposal, it was necessary. I used Dijod-Contrast of the medicine factory Medica, which is a 40 per cent solution of Na-diiodo-metan-sulphonic in water. In order to prevent possible peripheric disturbances, I applied a tourniquet on the thigh.)

2. Puncture of the artery in proximal direction with a cannula 0.8 mm of diameter, either percutaneously or laying free the artery immediately below the inguinal ligament.

3. Compression of aorta against the vertebral column by applying a compressive pad used in urography, which discontinues the pulsation of blood from the cannula.

4. Injection of the contrast medium as quickly as possible with ordinary syringes, 20—40 ccm, using connective rubber tubes to prevent the needle from shifting.

5. Taking of roentgen pictures immediately at the conclusion of injection in antero-posterior direction, with a plate-holder of 30×40 cm under the pelvis and another of 15×40 cm behind the thigh of the patient.

6. Removal of aorta compression, loosening of tourniquet on the thigh, removal of cannula, and compression of the place of puncture (with adrenalin tampon in cases where the artery had been laid free).

Aorta compression generally proves satisfactory, in case the patient is not exceedingly corpulent. When using 20 ccm of the contrast medium for the injection, it is regularly seen in the pictures as reaching at least to the point of bifurcation of the hypogastric artery. (Fig. 1.) When injecting 40 ccm of the contrast, it appears as extending far into the arteria iliaca communis, in many cases even beyond the bifurcation of aorta. (Fig. 2.)

Fig. 1.

Fig. 2.

Fig. 1. The contrast medium diffused as far as to the common iliac. Stenoses with a rugged surface in the external iliac and the superficial femoral totally obstructed.

Fig. 2. The contrast medium diffused as far as to the opposite side. The wall of the superficial femoral rugged below the point of injection.

My method of representing central parts of the arteries in the lower limbs, based upon aorta compression, means simplification of the technique. Because of the prevailing lack of contrast medium in Finland, I have at present no opportunity of developing the method further, without exposing patients to injuries ensuing from the use of contrast mediums containing iodine. In view of purely practical purposes, high arteriography is not even necessary, for palpation of the pulse, together with arterial murmurs ascertainable on auscultation, suffices for the diagnosis of stenosis situated in higher regions, because roentgenologic arterial changes and murmurs are, as I said, parallel phenomena. The common modern hand-books do not mention arterial murmurs in connection with peripheral disturbances of circulation. According to the investigations of Weber (1913), the systolic murmurs of this kind originate in eddies of

the blood stream, which are caused by irregularities of the vessel wall or by sudden changes in the size of the vascular lumen. The loudness of the sound which may even in normal cases be but feebly audible on the femoral artery and which can be strengthened by pressing the lumen with the stethoscope, depends, in accordance with physical laws, also on the rate of the flow, the thickness and elasticity of the wall, and the viscosity of the flowing fluid. In order to avoid possible misinterpretation, I have in several operations exposed the involved place of stenosis in conjunction with lumbar gangliectomy, and I have been able to establish by the aid of palpation the existence of sclerotic indurations and have felt below them the typical thrill (Schwirren).

SUMMARY

The author describes a method used by him in roentgenography of stenosed arterial processes occurring in the pelvic region. Compression of the aorta makes possible a retrograde diffusion of the contrast medium injected in the groin as far as over the bifurcation of the aorta to the opposite side. In patients with claudicatio intermittens central stenoses, in which also systolic sounds over the arteries occur as a symptom, are more common than is generally believed.

ZUSAMMENFASSUNG

Verf. beschreibt ein von ihm verwendetes Verfahren zur Röntgenphotographierung von hoch oben in der Beckenregion sitzenden stenosierenden Arterienprozessen. Aortakompression ermöglicht eine retrograde Ausbreitung der in der Leistenbeuge eingespritzten Kontrastflüssigkeit bis über die Aortabifurkatur hinaus auf die Gegenseite. Bei Kranken mit Claudicatio intermittens kommen zentrale Stenosen, die als Symptom auch systolische Nebengeräusche über den Arterien geben, häufiger vor, als man im allgemeinen vermutet.

RÉSUMÉ

L'auteur décrit un procédé qu'il emploie pour radiographier les processus artériels sténosants lorsqu'ils sont situés dans le haut de la région pelvienne. La compression de l'aorte rend possible l'extension rétrograde de la substance de contraste, injectée au pli inguinal, jusqu'au-dessus de la bifurcation aortique et vers le côté opposé. Chez les malades atteints de claudication intermittente des sténoses centrales, qui cliniquement s'accompagnent aussi de bruits adventices au-dessus des artères, sont plus fréquentes qu'on ne le croit généralement.

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FROM THE ROENTGEN INSTITUTE OF THE SZERETET HOSPITAL IN BUDAPEST

THE ACTION OF GRAVITY ON THE VISCERAL CAVITY[1]

by

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1. Syntopy of the orthograde cavity of the body

Considering the age of mankind from a phylogenetical point of view one might assert that Man has been walking for a disproportionately short time on two legs. We have several reasons to assume that the adaptation process of some of our inner organs to the upright way of living, *i.e.* to the human posture has not yet been concluded.

The race of quadrupeds from which man has developed is characterized by the horizontal position of the spine, in other words by the *pronograde* posture and gait; gravity acts therefore upon all viscera in a direction *perpendicular* to the long axis of the spine. As our ancestors progressed to the erect attitude and their posture became *orthograde*, this new state of equilibrium required a radical alteration in the machinery of support. The corresponding changes had been elucidated by comparative anatomical and anthropological studies long ago. Some time later, however, it became known that the situation of the viscera in relation to one another, *i.e.* their syntopy had been altered by orthogrady as well, further, that this new human resp. orthograde visceral topography was characterized by the vertically directed influence of gravity *parallel* to the long axis of the spine.

Our anatomical and physiological knowledge concerning the matter is still new and incomplete. Throughout centuries the internal structure of the human organism had been examined exclusively on lying bodies stretched out horizontally. Thus the anatomist performed the dissection of the viscera, and the surgeon opened the abdomen of the sick; even our clinical methods of investigations have been developed by means of

[1] With this paper the author whishes to express his profound gratitude to Swedish Radiologists who generously helped him in great distress to resume his research work.

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observations carried out on recumbent patients. First the roentgen examination enabled us to observe the cavities of the *standing* man overthrowing thereby a great amount of elder doctrines. The problem of the orthograde visceral syntopy requires exact roentgenbiological analysis by means of serial investigations on living subjects. The radiologist may connect his anatomical knowledge with physiological observations and will possess pathological experience, too, drawing important conclusions from them referring to physiological conditions. Changing the position of the body he has the chance to choose the most suitable ones for the purpose of practice and research, and thus to perform exact inquiries about gravitational effects on living subjects. Most of the corresponding observations have been well-known for a long time but »the leading principles of these functional-anatomical changes are missing so far» (MOLLIER).

Postmortem anatomy was sufficient as long as our knowledge was derived from the study of the lying human body and was controlled on the same. But roentgen experience awakened the interest for the orthograde syntopy of the viscera demonstrating *essential displacements in consequence of the cephalocaudal directed gravity*. Nevertheless, the principal question was rather the clarification of the rôle of the so-called ligamental fixations as regards the widespread interest in the etiology of visceroptosis considered as unsolved even to-day. Anatomical reports, however, relating to this matter are few, except the paper of HASSELWANDER which describes the visceral situs of three bodies fixed and dissected in the upright posture. In two of them the lungs were blown up and the influence of the high postmortem position of the diaphragm thus eliminated. He found excessive dropping of the whole gastrointestinal tract and of the liver as well. Even the retroperitoneal organs, considered before as firmly fixed, were situated *two vertebrae* lower than in bodies stretched out horizontally. Necropsy of the 3rd case, however, where the insufflation of the lungs was omitted, did not show any trace of the orthograde ptosis but the usual abdominal topography.

Confrontation of the latter case to the two formers displays undoubtedly that the maintenance of the abdominal situs depends first and foremost on the situation of the diaphragm. As a *mobile apparatus of support and adherence* the diaphragm secures not only the position of the adjacent organs but that of all the other abdominal viscera, too. It follows that the orthograde abdominal syntopy depends on *thoracic* forces determining decidingly the position of the diaphragm. Therefore, the effects of gravity exerted upon the thorax are also to be considered and the whole visceral cavity, *i.e.* the coelom investigated.

We shall name the biological sinking of the organs in orthogrady *visceroptosis ponderalis*. It manifests itself in all organs of the pleural

and peritoneal cavities which form the phylogenetically uniform visceral cavity, the coelom; it is one of the most outstanding characteristics of the orthograde way of living.

The visceral cavity or *coelom* (Fig. 1) is the part of the body which contains the thoracic and abdominal viscera; its components are the following: 1. The walls built of bones, cartilages, muscles and connective tissue; 2. the contents composed mainly of entrails; 3. the serous membranes lining the inner surface of the walls, and 4. the serous fluid securing the close adherence of the organs while allowing for the possibility of gliding movements.

One of the most important characteristics of the coelom is its hermetic closure by the air-tight adhesive contact of the contents. Owing to the property no organ can change its place without drawing along the adjacent ones.

The coelom of lower vertebratae forms a uniform cavity. The membranous and elastic partition, the diaphragm, appears first in mammals separating the interior into two portions. It is anchored all round the bony wall but its free central parts undergo positional changes on a large scale.

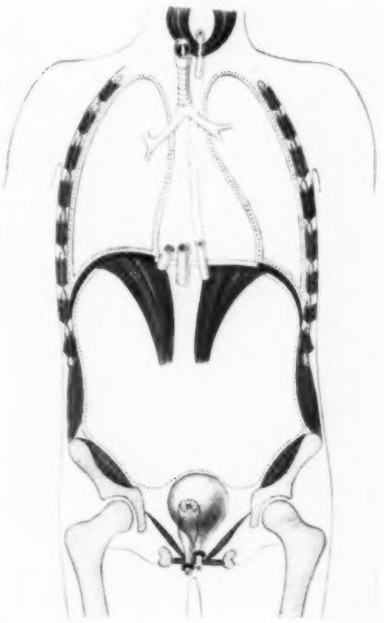


Fig. 1. A diagrammatic drawing of the common visceral cavity, the coelom. Muscles black, serous membranes in dotted lines. Both on the oral and caudal poles there are two sphincters; the openings of the diaphragm possess no sphincters. Hence the coelom forms an anatomical unity.

Both on the oral and caudal poles of the coelom there are two apertures with sphincters opening and hermetically closing the entrances. On the contrary the diaphragm does not possess any apparatus for constrictive functions. Consequently, the coelom remains an *anatomically uniform cavity* in spite of its division into two parts. If all the four sphincters are closed and the walls and contents of the coelom compressed, there results the »abdominal press» (correctly: trunk press). It is thus evident that the coelom acts as a uniform cavity from a *mechanical* point of view, too, and so the effects of gravity thereupon should also be treated uniformly.

Though the coelom thus forms an anatomical and mechanical unity, we shall separately deal with the effects of gravity exerted upon the peritoneal and the pleural cavities. By summing up our results we shall be able to obtain a full review of the influence of gravity upon the orthograde coelom.

2. Visceroptosis ponderalis

A. Abdominal organs. Roentgenbiological examination of the orthograde visceral syntopy gives valuable insight into the dynamics regulating the conditions of the coelom. The dropping of the abdominal organs diminishes from above downward and may be best analyzed on the stomach.

Authors agree that the striking difference in the *shape* of the stomach in the upright posture, in contrast to the anatomical form, is due to the vertically acting gravity. Two questions, however, are still to be settled: *a.* How does the *position* of the orthograde stomach change in relation to the fixed points of the skeleton and not to the adjacent organs shifting equally? *b.* Which are the forces counteracting the formal changes of the stomach in stout individuals? (The usual explanation by the help of »constitutional differences» does not satisfy mechanical thinking.)

The positional change of the stomach can be impressively illustrated by gluing a lead wire upon both branches of the costal arch and taking comparative films with exactly analogous technical conditions. The results of my numerous similar investigations may be summarized as follows (Fig. 2—3). The orthograde dropping of the stomach is a disproportionate one. The cranial portion shifts caudally together with the diaphragmatic dome owing to the hermetic contact of both; this displacement amounts to 3.5 cm. on an average. WYDLER found that the pylorus descended in the upright posture on a larger scale (9.2 cm. on an average). So it is evident that the stomach undergoes vertical elongation by sinking in orthogrady; on the other hand, it becomes at the same time *smaller in its horizontal diameter.*

Distention of an elastic body in one direction produces constriction perpendicular to the lengthening, designated in mechanics as cross-contraction. Beside solid elastic bodies, fluid- or gas-filled bags with elastic walls behave in the same way. We meet this significant *»diminution in transverse diameter»* continually in dealing with the mechanics of the visceral cavity (POLGAR).

The stomach is an elastic bag and its orthograde sinking and stretching involves considerable diminution in transverse diameter. This explains the *shifting of the descending pylorus toward the midline*, without regard to its situation in the right or left half of the abdomen. Owing

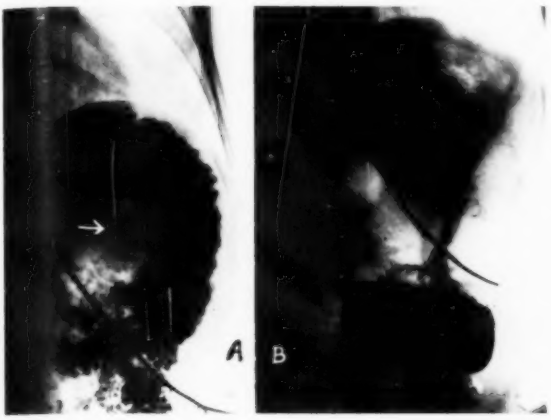


Fig. 2.

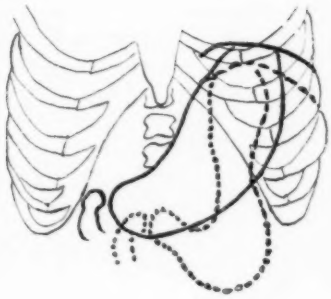


Fig. 3.

Fig. 2. A penetrating ulcer of the lesser curvature (arrow). Films taken with the costal arch marked by lead wire. (*A*) In the supine position the stomach is shortened and its cranial portion enlarged. — (*B*) In the erect posture the stomach is stretched out vertically, the pars media shows cross-contraction in the »pseudo-hourglass« form. The pylorus approaches the midline.

Fig. 3. Diagrammatic explanation of the orthograde change of form and position of the stomach. The fundus contacts the diaphragm and sinks together with the caudal shift of the latter; the antral part descends in a higher degree while sloping lateromedially.

to the cross-contraction all parts of an elastic body distended in one direction which lie outside the middle-plane are compelled to approach the middle-plane, and so does the pylorus (Fig. 2—3). The hourglass form of the stomach is in most cases merely another evidence of cross-contraction due to gravitational distention of the organ (Fig. 2). This *lateromedial shifting* is an important symptom of the visceroptosis ponderalis, recognizable on every portion of the abdominal contents situated laterally. The entire abdomen also represents an elastic, fluid-filled bag, the orthograde ptosis of which is consequently accompanied by a diminution in transverse diameter. Regarding further the conduct of the abdominal wall another important phenomenon can be observed.

If a horizontal line is drawn on the abdominal wall of a supine subject at the height of the umbilicus and observed then in the erect posture (Fig. 4), it is easy to demonstrate that the sinking of the medial portions surpasses that of the lateral ones. A distended elastic body fixed on two ends shows the minimal elongation near the fixed points and the deformation grows gradually up to the middle distance. The abdominal wall

behaves in the same way, as it is fixed on the flanks to the ribs as well as to the pelvis but free in the front.

This unequal sinking of the abdominal wall draws the organs along. Furthermore, the dropping of the viscera is larger in the midabdominal portions also in consequence of the funnel-like shape of the pelvis. Opposition and counterpressure of the piled-up pelvic organs are therefore smaller in the vicinity of the midsagittal plane than laterally where the fixation of the abdominal walls and the stiff iliac bones counteract the ptosis. — In order to answer the question *b* »Why is the sinking of the stomach not found in stout individuals of the hypersthenic type?» we have to consider first the forces opposing gravity, viz. the elastic thoracic suspension and the resistance of the abdominal wall.

The orthograde ptosis of the separate segments of the *large intestine* is quite different. The position of both flexures depends on the position of the body just as that of the cranial stomach parts. As the flexures do not contact the diaphragmatic domes their shifting is often larger than that of the fundus. The cecum slips down in the upright posture below the linea terminalis shifting medially at the same time. This phenomenon displays a further proof of the rule according to which every organ situated laterally slopes toward the midline. The dropping of the transverse colon is unequal. In consequence of the larger ptosis of the viscera in the midabdominal portions the wellknown guirland- or V-form of the transversum gets developed in standing (Fig. 9). The sinking fails to occur in pycnic subjects on account of the thoracic forces discussed later. Finally, we know that the highest point of the sigmoid may reach the navel in the lying position and slips down as far as the promontorium in standing.

The loops of the *small intestine* are the most mobile parts of the abdominal contents; thus they are submitted to the highest degree to the force of gravity. They are situated mostly in the small pelvis in the upright posture and scattered over a higher area in lying.

Positional changes of the *liver* and of the *gall-bladder* due to gravity can be studied by cholecystography, which disproves the elder doctrine according to which the situation of the gall-bladder as well as of the lower border of the liver correspond to the costal arch. Comparative films exhibit the shifting of the gall-bladder medial while sloping down and its simultaneous diminution in transverse diameter. The position of the liver depends on the situation of the diaphragm equally to that of all other subphrenic organs.

The position of the *kidneys* is similarly a function of the situation of the diaphragm in consequence of the firm connection between the renal fascia and the diaphragm. Films taken in the upright and horizontal position show that the displacement of the kidneys in orthogrady equals

that of the lumbar portions of the diaphragm; BACON found an average physiological dropping of 5—6 cm.

According to my observations the measure of the orthograde ptosis of the gall-bladder and that of the kidneys amounts to the height of two vertebrae, *i.e.* to the same distance found by HASSELWANDER in dissections and by WYDLER concerning the pylorus. Absolute numbers are unimportant in this regard. The essential fact is that all the organs are submitted to the same force and behave in the same way in slipping down, meanwhile the organs or portions situated laterally shift medialward and the ptosis increases lateromedially.

The orthograde ptosis of the *pelvic viscera* is inconsiderable owing to the resistance of the pelvic floor. But the bladder sinks deeper little by little in the course of postnatal life; it reaches the navel in the newborn infant and lies behind the symphysis in old age. KEITH states that »a natural visceroptosis takes place at the lower end of the abdominal cavity of all orthograde primates, as adolescence is reached».

B. Thoracic organs. The walls and the contents of the chest have hitherto been neglected in the study of visceroptosis. This is due to the fact that gravity alters the position of the abdominal organs *in toto*, evolving also some changes in form. Contrary to this, the thoracic organs undergo mere changes in form in orthogrady, which are, however, of high practical and theoretical importance. This diversity is caused by the different fixation of the organs of the peritoneal and pleural cavities. The upper abdominal organs adhere to the diaphragm which is a support of great mobility, whereas the lungs are fixed immovably on the apices by the force of adherence, and the heart is carried by the strongly fastened system of vessels.

Anatomy teaches that »the spine in the upright position with the aid of the far-protruding osteothorax and the rings of ribs functioning as beams transporting the load, supports the weight of the abdominal viscera» (MOLLIER). Yet neither the diagram (Fig. 5) nor the text consider the fundamental fact that the upper abdominal organs hang on the diaphragm and thus the abdominal load is partly transmitted by the mediation of the diaphragm on the thoracic suspensory apparatus.

In analysing ptosis one has always to consider that owing to the hermetic seal no organ can change its situation without drawing along the adjacent structures, esp. those below or above the moving one. In view of this we have to put the question: If the descending subphrenic viscera pull down the diaphragm, what happens to the thoracic organs adherent to the diaphragm — that is, how do the lungs and the heart conduct themselves? Furthermore, we have to examine also the thoracic walls, since we already saw that beside the contents the walls of the coelom, too, participate in the sinking; there exists no *visceroptosis* but only a

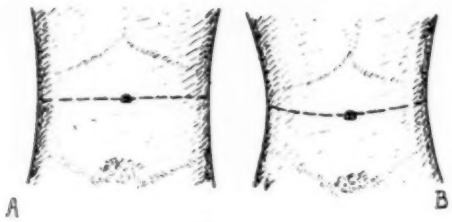
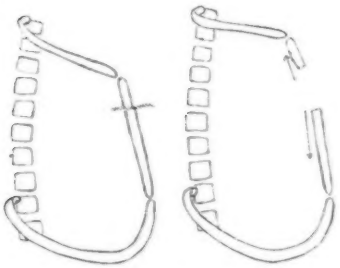


Fig. 4.



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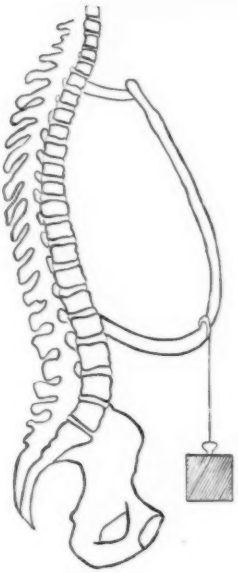

Fig. 5.

Fig. 4. Effects of gravity upon the abdominal wall. (*A*) A horizontal line drawn across the abdomen of a lying subject. — (*B*) The same subject in the upright posture; the midabdominal portions of the wall sink in a higher degree than the lateral parts. (Tracings of photographs.)

Fig. 5. The weight of the abdominal organs loads the osteothorax in the upright posture. (Redrawn from MOLLIER.)

Fig. 6. Braune's experiment. The breastbone of a vertically suspended body having been sawn across, the upper part of the thorax arises while the lower one moves caudalward.

coeloptosis! In regarding the coelom as a mechanical unity the answer to the complex problem of ptosis reveals by itself.

When the upper abdominal organs descend in orthograde in consequence of their own-weights pulling the diaphragm down, then the lungs and the heart, bound mechanically to the diaphragm, become distended in a vertical sense and, at the same time, contracted in the transverse direction. The elastic thoracic walls, coupled mechanically to the diaphragm as well, are subjected to the same changes. These changes of form upset the mechanical equilibrium of the visceral cavity and induce some potential energy to the elastic parts of the chest which behave like any deformed elastic body loaded by some weight. The evidences of this fundamental biological phenomenon are: (1) The experiment of Braune; (2) comparative

roentgenograms of the chest; (3) the analysis of the lung capacity; (4) the conduct of the thoracic walls, and (5) alterations of the shape of the heart.

(1) *Braune's experiment.* Sawing across the breastbone of a body suspended vertically after the costal spaces were emptied and the lungs detached, the upper part of the chest tips up while the lower moves downward (Fig. 6). It is proved by this that the orthograde osteothorax charged by the weight of the coelom will be unbalanced, storing up some potential energy like a loaded helical spring. By discharging the spring the initial situation returns, as the rings of ribs elevate.

(2) The comparison of chest roentgenograms taken in standing and lying exhibits results fully analogous to those of Braune's experiment. The sternal ends of the ribs sink in orthogrady and the costal spaces enlarge like a fan. So the osteothorax stretches itself like a loaded coiled spring. In addition, the lung fields are in the upright position far more transparent than in lying. This is due to the orthograde weight of the abdomen which pulls down the diaphragm producing thus vertical elongation of the lungs, the intraalveolar septa of which become thinner (= diminution in transverse diameter). There results an increase of the air-filling of the lung and decrease of the specific gravity of the parenchyma.

(3) It can be proved by spirometry that the vital capacity, the normal capacity as well as the amount of residual air are greater in standing and sitting than in lying. These facts are further evidences that the specific gravity of the lung tissue decreases in orthogrady. As the descent of the diaphragm, caused by the abdominal weight, increases the capacity of the thoracic cage and distends the lungs apicocaudally, these changes evidently compel a shifting of the state of rest of the respiratory apparatus in the sense of inspirium.

(4) The vertical distention of the chestwalls and of the lungs by the abdominal weight brings about shortening of both the transverse and anteroposterior diameters of the thorax on account of cross-contraction. Comparative orthodiagrams demonstrate the conspicuous constriction of the thorax at the level of the diaphragm in orthogrady (Fig. 7). The development of the »taille» in consequence of orthograde cross-contraction, and its increase and decrease can be measured even with a measuring tape. This elastic constriction of the trunk-wall is also one of the outstanding features of the upright way of living (Fig. 8, 12).

The trunk-wall is submitted by the weight of the orthograde coelom to the following formal changes: The portions below the umbilicus are bulged out in the direction of the smallest opposition, viz. against the anterior abdominal wall, whereas the higher parts undergo a diminution in transverse diameter pulled down at the same time.

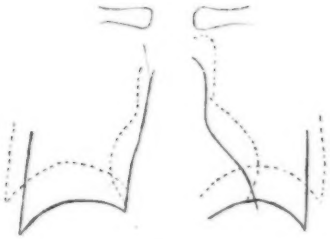

Fig. 7.

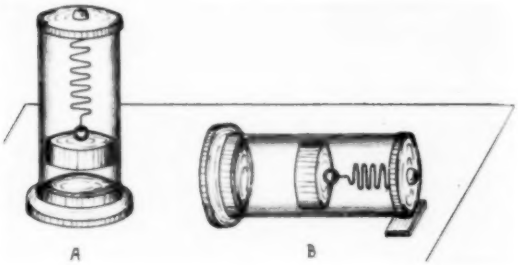

Fig. 8.

Fig. 7. A diagrammatic drawing of the diaphragm in the supine (.....) and in the erect (————) posture. The side-to-side diameter of the thorax shortens in the upright position. (Redrawn from HITZENBERGER.)

Fig. 8. A model of the pondero-elastic equilibrium. (*A*) In the upright position the weight of the abdomen stretches the elastic thoracic suspensory apparatus vertically. — (*B*) In the lying position the discharged thoracic apparatus shortens and draws the abdominal contents upward.

(5) The base of the heart, bound firmly to the diaphragm, descends with the latter in orthogrady; the heart is pulled lengthwise and so its transverse diameter is lessened (Fig. 7). It has not been sufficiently emphasized so far that this well-known alteration is due to the orthograde load of the abdominal viscera, transmitted upon the heart by the intermediate diaphragm. Thus the heart behaves analogically to the lungs and the chestwalls, and its change in form also proves that the weight of the subphrenic organs is carried (beside the osteothorax) partly by the thoracic viscera.

The lungs as well as the thoracic walls are characterized by their elasticity from the standpoint of gravitational phenomena. Accordingly, we understand that the term *thoracic suspensory apparatus* in the following indicates the sum of the elastic components of the chest balancing the abdominal weight.

3. The pondero-elastic equilibrium

The orthograde coelom considered as a mechanical unity displays an equilibrium remarkably changed in relation to the pronograde situation. The viscera descend in consequence of their own-weights until an equilibrium between the force of gravity and of the elastic thoracic forces, directed upward, is stabilized. I intend to call this state of balance, characteristic of all orthograde primates, *pondero-elastic equilibrium*. In order to be acquainted with it one has to take cognizance of the fol-

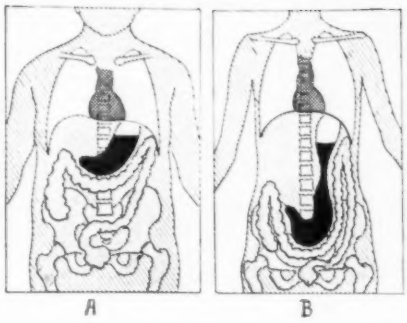

Fig. 9. (*A*) Hypersthenic type; the chest is short and wide showing no taille. High transverse conoidal form of the stomach. — (*B*) Longitudinal and relatively narrow chest with well-marked taille. »Pseudo-hour-glass» form of the stomach owing to cross-contraction. Guirland-shape of the transverse colon.

Fig. 10.

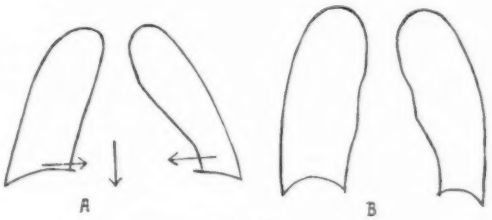

Fig. 11.

Fig. 10. (*A*) The course of the lower costal arch of the newborn infant is nearly horizontal. — (*B*) The costal arc of the adult displays a sharp curve.

Fig. 11. The thorax of the newborn child (*A*) is bell-shaped. — In orthogrady the elastic lengthening of the osteothorax produces narrowing of the lower operculum in consequence of cross-contraction (*B*).

lowing simple laws of elasticity: *a*. The elastic potential; *b*. the law of elastic extension, and *c*. the imperfect elastic recoil.

a. *Elastic potential*. That body is called in daily life elastic, that is capable of storing up energy employed to its deformation in an easily reversible way and almost without any loss. According to PLANCK, the elastic potential is the potential energy of the deformation which will be transformed into kinetic work while the body regains its natural conditions. Thus the strained spring of a watch, the bent chord of a bow or, in the organism, the ribs elevated by inspiration or the walls of an expanded vessel, all possess a certain quantity of elastic potential.

Elevation of the elastic potential may be recognized on the loaded thoracic suspensory apparatus as readily as on a loaded coiled spring by the elongation and the cross-contraction of the chest. Realizing this fact we become aware of the following fundamental biological discovery:

If the orthograde load ceases and the body resumes the horizontal position, then the elastic thoracic potential performs kinetic work and yields the energy

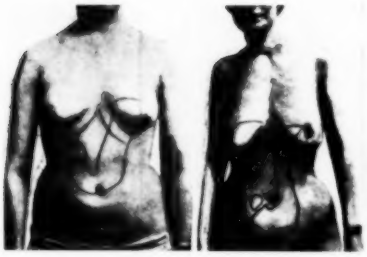

Fig. 12.

Fig. 13.

Fig. 12. Ptosis of the coelom wall, low position of the diaphragm, gastroptosis in connection with the dimensions of the chest, corresponding to the ratio of length to breadth. (From FABER.)

Fig. 13. A comparative anatomical study of the diaphragm. *a*) Arched form of the diaphragm of the human fetus; *b*) diaphragm of the rat performing a membrane stretched out flatly.

which raises the dropped abdominal organs and the diaphragm into their initial situation. The ribs arise, the lungs and the heart shorten and the narrow taille enlarges. The pronograde state of equilibrium which has been disturbed by the orthograde load of the coelom will be restored once more. Accordingly, a movement of pendulum is performed in the coelom which can be demonstrated by a simple apparatus (Fig. 8). The model displays only the deciding principle of the process, neglecting the varieties of the specific elasticity of the thoracic elements, the resistance of the abdominal wall, and, finally, the rôle of the diaphragm which will be discussed later.

b. The law of elastic extension. Qualitatively the elastic extension is characterized by cross-contraction. Quantitatively the size of the deformation is proportional to the effective force. The magnitude of elongation (E) is defined by the following equation:

$$E = P \cdot \frac{1}{R} \cdot \frac{L}{Q}$$

where P denotes the acting force or weight, R the specific elastic resistance of the substance, L the length and Q the cross-section of the body.

This well-known equation explains all the individual differences of the ponderic ptosis. We may regard P, *i.e.* the orthograde weight of the abdomen as well as the specific elasticity of the thoracic components R as constant magnitudes in healthy adults $\left[\frac{P}{R} = C\,(\text{constant})\right]$. Therefore, the elastic elongation of the upper coelom-half which makes possible the descent of the lower one, stands in a direct proportion to the length

of the chest and in an inversed ratio to its cross-section. By substituting the corresponding values for P and R we may write:

$$\text{Elongation} = \text{degree of ptosis} = C \cdot \frac{\text{length}}{\text{cross-section}} \text{ of thorax.}$$

This mathematical formula of the pondero-elastic equilibrium shows thus unmistakably that the measure of ptosis depends first of all upon the *form of the chest*, *i.e.* from simple physical factors. By reducing the ptotic phenomena to this physical law we can fully renounce the obscure conceptions of »constitution», »habitus» and others, as we can bring into relation the measure of ptosis merely with the physical structure of the chest. So it becomes quite evident why excessive ptosis occurs in »hyposthenic» individuals with long and slim thoraces, and why the stomach of the stout and short-bodied »pycnic» shows the bull-horn form in the upright posture with the transverse colon maintaining its pronograde course. So we see on Fig. 9. choosen at random out of one of the textbooks that ptosis develops simultaneously with the constriction of the waist, when the length of the vertical axis of the chest surpasses its transverse diameter (9B). and is omitted when this relation is an inversed one (9A).

Based upon this discovery it might be maintained beyond dispute that the body built of Man has not yet been fully adapted to the orthograde way of living which requires a highly appropriate thoracic construction. This statement is also proved by the phylogenetical evidence of the progressive broadening of the chest, proportionately to the length of the trunk as we proceed from lower pronograde apes to orthograde anthropoids and Man.

c. Incomplete elastic recoil. If the action of the outer force ceases, the elastic body regains its former shape and size. If the deformation, however, lasts too long or is too often repeated, there remains permanent change of form (elongation or shortening, etc.); physics calls this: incomplete elastic recoil. The thoracic suspensory apparatus is subject to this law, too.

The rings of ribs of the newborn infant have an almost horizontal course, but their sternal parts sink continuously on account of the daily repeated vertical load, and the lower border of the costal arch approaches the pelvis. The whole chest sinks during postnatal life little by little together with its contents. This is proved by the progressive dropping of the diaphragm (MEHNERT) and by the descent of the larynx which stands at the level of the 3rd cervical vertebra in the newborn and sinks as far as the 7th in old age. The stiffness of the thoracic cage increases with adolescence. If the deformation of the thoracic cage and the sinking of the diaphragm become *irreversible* on account of the incomplete elastic recoil, senile ptosis develops. The incomplete elastic recoil is thus the

biological limit which all human beings are bound to reach sooner or later; it becomes thus a source of serious sequelae.

Physiological changes of the pondero-elastic equilibrium take place step by step in the course of postnatal life.

(1) The walls of the coelom as well as the visceral syntopy of the *newborn child* present altogether the characteristics of the pronograde situs. His rings of ribs are directed horizontally, his diaphragm occupies a high position with the heart lying transversely. The stomach has the transverse conoidal shape, the transverse colon follows a straight course across the abdomen, and the bladder is placed at a high level. The newborn infant spends his whole time in the horizontal posture, and thus his body does not know the orthograde ponderic ptosis, as he does not know the upright way of living either with all its enjoyments and »gravities» . . .

(2) The *young child* performs his first experiments of locomotion just like a pronograde animal creeping on all fours. When he erects his body he behaves like our primitive ancestors, as he has to clutch some firm support with his upper limbs. While learning to stand and walk each individual repeats the way pursued by human race till orthogrady has been achieved. The forces of the pondero-elastic equilibrium develop together with the organs of balance; this is evident by the striking protrusion of the young child's abdomen, since the preponderantly cartilaginous thorax of the young does not suspend the abdominal load as firmly as that of the adult; thus the pressure of the abdominal weight, unbalanced from above, causes the wall to protrude. With the calcification of the thoracic cage the suspensory apparatus strengthens and resists steadily the orthograde load; henceforth the protrusion of the abdomen disappears.

(3) *Adolescence* is characterized from the standpoint of the pondero-elastic equilibrium by the gradual reconstruction of the osteothorax. The lower border of the costal arch approaches the pelvis and its course changes from a horizontal line into a curved form (Fig. 10).

The cross-contraction of the lower thoracic operculum, brought about by the orthograde load of the coelom, is of the utmost importance for the configuration of the trunk. The thorax of the newborn infant displays the bell-shaped pronograde type broadest at its lower opening. On the contrary, the chest of adults is constricted at its inferior aperture owing to the cross-contraction which becomes persistent in consequence of incomplete elastic recoil (Fig. 11). So there develops the slendering of the waist, the taille, that becomes more accentuated in orthogrady. Gravity thus exerts a far-reaching influence on the development of the human body built. This is proved by the fact that the chest form of idiotic children, unable to learn to sit and walk, maintains its newborn

(correctly: pronograde) type without a constriction of the lower operculum, even in the 2nd or 3rd life-year of the child.

(4) In the *ripe age* the pondero-elastic equilibrium of the adult, once established, remains unchanged during some decades. Probably the calcification of the rib-cartilages plays a part in the stabilization of balance increasing the power of support of the osteothorax. It is most remarkable that this process, unexplained so far, starts between the years 20—24, immediately after the bony system has completely developed. Accordingly, the calcification of the rib-cartilages appears to be a reactive process produced by the effects of gravity.

The orthograde slendering of the waist, as a further characteristic of maturity, is one of the outstanding features of Man's upright posture. Artists always knew that only the standing nude was presenting a slender »wasp» waist which rather disappeared in recumbency. This positional alteration of the taille is of a great practical and theoretical importance; it can easily be measured with the measuring tape and a pair of compasses fitted to determine intervals from 0.25 cm. onward.

The conspicuous transverse constriction of the waist in connection with the sinking of the coelom wall is to be seen on Fig. 12 which demonstrates clearly the relation of these outer features of the thoracic built with the low position of the diaphragm and consecutive gastroptosis.

My observations showed that the orthograde diminution of both the circumference and the transverse diameter at the level of the 9th or 10th rib may amount to as much as 6 cm. The narrowing of the waist of women is more conspicuous, since their pelvis is relatively broader and fatter. One finds the greatest constriction in the hypersthenic type whose trunk is short. The diminution of the waist circumference in orthogrady disappears, however, in cases of rigidity of the thorax as it is to be found in old age and in emphysema. Thus the comparative measuration of the taille is a useful help in the diagnosis of emphysema.

(5) In *old age* the thorax descends further chiefly on account of senile kyphosis. The simultaneous loss of lung elasticity relaxes the diaphragm to a low level that is followed by consecutive visceroptosis described by Vogt (1921) as ptosis senilis.

This hasty review demonstrates that the upright way of living brings about various lesions upon the inner organs and body walls of the primates. This is the price the biped has to pay for the advantages of the erect posture and gait.

Examples of *pathological disorders* of the balance between abdominal load and thoracic suspensory force are revealed by the symptoms of rickets and emphysema.

The elastic resistance of the *rachitic thorax* decreases on account of the failure of calcification of the ribs. There results a deep impression on

the lower rings of ribs, the HARRISON's sulcus presenting itself on the same level where the constriction of the healthy appears; it remains persistent owing to the incomplete elastic recoil. A further evidence of the reduced thoracic suspensory force is the rachitic frog-belly, since the abdominal weight charges the front-wall heavier, the elastic counterpull being diminished. The frog-belly disappears, when remineralization of the ribs takes place in the course of healing.

The state of *alveolar emphysema* resembles to that of old age. The force of the coelom weight overcomes the decreased resistance of the unelastic and distended lung-tissue, and produces dropping of the diaphragm with secondary visceroptosis.

In some conditions, on the other hand, the retractile power of the lung increases proportionally to the density of the parenchyma (PARODI) like in the manifold condensations of the lung. Atelectasis, massive collapse, pneumonia, infarction, postmortem lack of airation, etc. increase the pulling force of the lungs. The common symptom of all these states is the upward displacement of the diaphragm with elevation of the subphrenic organs. The juxtaposition of these changes in contrast to the situs in emphysema reveals impressively that the diaphragm, inasmuch as its muscle elements and innervation are intact, is the indicator which records the overweight of either the elastic thoracic or the ponderic abdominal forces. In other words, the diaphragm is the *hand of balance* of the pondero-elastic equilibrium.

4. Visceroptosis as a biological problem

We have considered the ponderic ptosis so far from a mechanical standpoint and found ist fundamental definition in a simple mathematical formula. Now we have to ask: If the action of gravity upon the orthograde coelom is physiological, are we entitled at all to speak of pathological ptosis? Further, if so, where does the borderline between physiological and pathological ptosis lie?

Before attempting to find the answer we still have to deal with *a*. the rôle of the abdominal wall, and *b*. the function of the diaphragmatic dome.

a. Though the law of elastic elongation expresses the very essence of ptosis, its validity is restricted, since the abdominal organs do not hang freely but in a closed bag. The resistance of the abdominal wall diminishes the ptosis; its normal tension, however, can not impede the dropping, recognizable by the protrusion below the umbilicus in orthogrady.

The rôle of the abdominal wall has doubtlessly been overestimated in the problem of ptosis, as neither diseases nor congenital anomalies

involving exclusively the abdominal wall are known. If the weigh t of the viscera is unbalanced from above, it charges the wall heavily and bulges it out permanently on account of incomplete elastic recoil. Stret ching and thinning of the wall are rather the *sequelæ* than the cause of ptosis. The hanging-belly of the multipara develops in the same way. Considering, however, the small number of the latter in relation to the millions of ptotics, one understands that the key of the problem can not lie in the function of the abdominal wall. The thoracic suspensory force plays a disproportionately greater part in the actual orthograde syntopy than the abdominal resistance does.

b. The retractile power of the lung does not exert its full action upon the abdominal organs. Inserted between them there lies a brake: the diaphragm, the tonus of which diminishes the lung force. If the brake does not work the diaphragmatic tension being lost (as in phrenic paralysis, eventeration or in dead bodies) the lungs pull the abdominal contents higher into the thoracic cavity. On the contrary, by tearing the brake forcibly the diaphragm balances the whole pulling effect and the viscera descend, as it may be observed in hiccup or in pushing the abdomen forward.

The shape of the diaphragm of quadrupeds is more or less flat and set generally in an oblique position. The diaphragmatic domes of primates, on the contrary, are nearly horizontal and, at the same time, vaulted strikingly (KEITH); their muscularization increases in extension as well as in thickness in orthogrady. In my opinion, based upon mechanical considerations and comparative anatomical studies, nature thus provided the primate with a stronger and more enlarged supporting apparatus. The large surface of his muscular and arched diaphragm supplies him with a more adequate device for the adherence and support of the abdominal load than the flat membrane of pronograde animals does (Fig. 13). Approximate calculations prove that the arched diaphragm of man offers a 25 % larger supporting surface than a membrane stretched out flatly.

Knowing these facts we may reply to the question whether the biological ptosis could be distinguished from the so-called pathological ptosis. Considering the problem from the point of view of gravitational effects the right answer approaches at once. Nature knows neither rules nor exceptions but only great principles of universal validity including both the rule and the exception. In the manifold image of ptosis we have also to deal with a universal principle — that is with the action of cephalocaudal gravity upon the coelom. This can be influenced and altered by various components. One has to take into consideration: the alterations of the lung-elasticity and of the chest walls, the resistance of the abdominal wall, the shape of the diaphragm; but of the utmost signif-

icance there are the dimensions of the chest, namely the ratio of its length to its breadth. Only the analysis of all these factors gives an explanation for the so-called constitutional differences, for the great number of transitions, for all the physiological alterations and pathological disorders of the pondero-elastic equilibrium. *Visceroptosis is the professional disease of Man's erect posture*, for his organism has not yet been fully adapted to the upright attitude and gait acquired phylogenetically in a recent period of the biped's life time.

This conclusion results from the roentgenbiological analysis, still relatively new. In the early days of the roentgen era physicians were astonished by the higher position of the diaphragm in lying subjects, having been formerly taught the contrary. So they wondered why the diaphragm did ascend in recumbency and supposed that the abdominal pressure, increased in lying, displaced the diaphragm upward. The fallacy of this explanation becomes evident at once, if we consider that the diaphragm maintains its high position even in the dead body after the evisceration of the abdomen, *i.e.* without any abdominal pressure. The old answer was false, because the question itself had been put in a wrong way. The point in question is not: Why the diaphragm does *ascend* in lying, but: why it did *descend* when Man's ancestors placed themselves upon their hindlegs for the first time? It descended, as it was pulled down by the weight of the abdominal organs, and so it does every day when we get up in the morning. The human organism starts every morning once more with the adaptation to the upright posture. So biology has also to start again and again with the study of the effects of gravity upon the body, until we shall be in possession of sufficient evidences to answer exhaustively all questions referring to these phenomena.

SUMMARY

Gravity acts on all the components of the common visceral cavity, the *coelom*, which is to be considered as a mechanical and anatomical unity. The abdominal organs sink in orthogrady and pull down the diaphragm so far until the resistance of the thoracic suspensory apparatus stops the movement. If the body assumes the lying position, the potential elastic energy of the discharged thoracic suspension raises the organs dropped in the erect posture. The pondero-elastic equilibrium represents the balance between the weight of the coelom and the upward acting thoracic force; the diaphragm is the hand of this balance. Visceroptosis is the professional disease of man's posture in individuals whose constitution has not yet been adapted to the upright way of living, acquired in the phylogenetical sense only since a relatively short time.

ZUSAMMENFASSUNG

Die Schwerkraft beeinflusst sämtliche Komponenten der allgemeinen Viszeralhöhle, das *Zölom*, das als eine mechanische und anatomische Einheit anzusehen ist. In aufrechter Stellung sinken die Bauchorgane herab und ziehen das Zwerchfell herunter, bis der Wider-

stand des thorakalen Aufhängeapparats die Bewegung aufhält. In liegender Stellung zieht die potentielle elastische Kraft der jetzt entlasteten thorakalen Aufhängung die in aufrechter Stellung herabgesunkenen Organe wieder hoch. Das pondero-elastische Equilibrium stellt das Gleichgewicht zwischen dem Gewicht des Zöloms und der aufwärtswirkenden thorakalen Kraft dar; das Zwerchfell ist der Zeiger dieses Gleichgewichts. Viszeroptose ist die Berufskrankheit der menschlichen Stellung bei Individuen, deren Körperbau sich noch nicht der im phylogenetischen Sinne erst seit verhältnismässig kurzer Zeit erworbenen aufrechten Lebensweise angepasst hat.

RÉSUMÉ

La pesanteur agit sur toutes les parties constitutives de la cavité viscérale commune, le *coelome*, qu'il faut considérer comme une unité mécanique et anatomique. Les organes abdominaux s'abaissent dans l'orthostatisme et attirent le diaphragme jusqu'à ce que la résistance de l'appareil suspenseur thoracique arrête le mouvement de descente. Quand le corps prend la position couchée, l'énergie potentielle élastique de l'appareil suspenseur thoracique, qui n'est plus mis à contribution, remonte les organes qui s'étaient abaissés dans la position debout. L'équilibre pondéro-élastique est celui d'une balance à ressort sur laquelle le poids du coelome agit de haut en bas et la force thoracique de bas en haut; le diaphragme est l'aiguille qui tient cette balance. L'entéroptose est la maladie professionnelle attribuable à la station debout de l'homme; eller apparaît chez les individus dont l'anatomie ne s'est pas encore adaptée à la vie orthostatique, qui est, au sens phylogénétique, une acquisition relativement récente.

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